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OF THE

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Volume V.

SACRAMENTO:
STATE OFFICE : : : J. D. YOUNG, SUPT. STATE PRINTING.
1880.

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REPORT

OF THE

STATE ENGINEER

TO THE

Legislature of the State of California--Session of 1880.

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SACRAMENTO:
STATE OFFICE : : : : J. D. YOUNG, SUPT. STATE PRINTING.
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LETTER OF TRANSMITTAL.

SACRAMENTO, California, January 21st, 1880.

Hon. John Mansfield, President of the Senate, State of California:

SIR: I herewith submit Parts I and II of my official report to the Legislature, being a report on the "History of operations" conducted under my charge, and a report on the "Drainage of the valleys, and relief of rivers when in flood," referring particularly to the Sacramento Valley drainage, with an incidental treatment of the debris problem, and also to the drainage of the San Joaquin Valley, and the improvement of the navigation of the San Joaquin River.

Accompanying you will find a letter introductory to the entire report, and addressed to the Legislature.

I also transmit a communication from Col. G. H. Mendell, consulting Engineer.

Very respectfully,
Your obedient servant,
WM. HAM. HALL,
State Engineer.

INDORSEMENT OF CONSULTING ENGINEER.

SACRAMENTO, California, January 21st, 1880.

To the Legislature of the State of California:

I have been, throughout the history of the State Engineer Department, familiar with the character and scope of its field operations. I have also read the report of the State Engineer, so far as it has been prepared, and have consulted and agreed with him in regard to its main propositions.

When the remaining chapters of the report shall be completed, I expect to submit my views upon the general subject.

I am, very respectfully,
Your obedient servant,
G. H. MENDELL,
Consulting Engineer.

REPORT.

INTRODUCTORY LETTER.

Office of the State Engineer,
Sacramento, January 10th, 1880.

To the Honorable the Senate and Assembly of the State of California:

Under and by virtue of an Act of the Legislature of the State of California, entitled "An Act to provide a system of irrigation, promote rapid drainage, and improve the navigation of the Sacramento and San Joaquin Rivers," approved March 29th, 1878, I am required to submit to the Legislature now assembled a report embodying, (1) "A full statement and history of the operations" conducted under my direction up to the first day of January, 1880; (2) "A statement of the condition of the inquiry" with which I am charged; (3) "A statement of the important facts that have been ascertained either accurately or approximately"; (4) A statement of "the deductions or recommendations which have been justified by the inquiry, in regard to the principles which ought to govern in the irrigation of lands, and the relief of rivers when in flood;" together with (5) "Such practical recommendations as the State Engineer may see fit."

The above outline of what is required of me at this time, is taken from paragraph 17 of section 4 of the Act referred to.

Section 3 of the same Act says "the duty of the State engineer shall be, under the direction of the Governor, to investigate the problems of the irrigation of the plains, the condition and capacity of the great drainage lines of the State, and the improvement of the navigation of rivers."

Succeeding portions of the law set forth more explicitly the nature of the several inquiries to be made and in addition to what had been outlined. One of these imposes the duty inquiring into and reporting upon "the question of the flow of debris from the mines into the streams," and "the injury to agricultural lands by the flow of debris thereon."

Under these instructions the work in the State Engineer's Department has been carried since May, 1878, and I shall now have the honor of reporting to you as required by the law.

The inquiries or examinations which I am expected to make are naturally grouped under three headings, as follows: Those concerning rapid drainage and improvement of navigable streams.
The flow of mining detritus—its extent, effects, and possible remedies therefor; and irrigation of the dry plains.

Although the subjects which I shall have to discuss are thus separated for convenience of consideration, the intimate connection between each couplet, and all of them, is such that the parts of the report will be interdependent, and to avoid much repetition, references will be made from one to another. Thus the order in which they are prepared and presented has been governed to a considerable degree by the importance which each bears to the whole line of treatment.

Further than this, the history of operations, etc., which I am required to submit constitutes a separate class of matter, and by its nature is to be stated preliminary to all else.

And still again, I am required to give "An account of the present condition of the inquiry," which will necessitate a statement of what remains to be done in order that the benefit may be derived from the expenditures thus far incurred. The concluding part of my report will be devoted to the matter.

Thus, there are five distinct subjects to be treated of, and I have divided the report into as many parts, and have arranged the order indicated above.

For the sake of brevity and clearness of presentation, I have grouped the data and special discussions—which could be thus placed outside of the general argument or statement of the report—into certain separate papers and exhibits, which will be appended to the several parts of the report, each as befits the nature of its contents.

For a more concise yet extended statement of the nature of the papers to be submitted, I call your attention to the *outline of subjects reported upon* which is hereunto annexed.

It has not been possible for me to prepare all of these papers for submission during the first days of your session, but the several parts of the report with the appendices will be laid before you at the earliest dates practicable.

Very respectfully,
Your obedient servant,
WM. HAM. HALL,
State Engineer.

OUTLINE OF SUBJECTS REPORTED UPON.

PART I. History of operations of the State Engineer Department.
PART II. Drainage of the valleys and improvement of navigable rivers.
PART III. The flow of mining detritus.
PART IV. Irrigation of the dry plains.
PART V. The present condition of the inquiry.

PART I.

HISTORY OF THE OPERATIONS OF THE STATE ENGINEERING DEPARTMENT.

The objects, nature, extent and manner of the performance of the work undertaken by this Department will be set forth in this part of the report, under the following sub-headings:

The objects and work of the State Engineering Department;
The problems of drainage;
The debris problem;
The problems of irrigation;
The field for examination;
Organization of force;
The drainage surveys and examinations;
The irrigation surveys and examinations;
Miscellaneous surveys, examinations, and observations;
Synopsis of results;
Re-examinations and observations;
Office work.

PART II.

DRAINAGE OF THE VALLEYS, AND IMPROVEMENT OF NAVIGABLE RIVERS.

In this part of the report the above mentioned subjects will be discussed at length in a general review of the situation and a consideration of the various possible plans for remedying existing evils, particularly in the Sacramento Valley. The subject of the flow of debris will be touched upon only so far as essential to the general line of argument in the drainage problems, reserving a more detailed account and consideration of it for the special paper next given. The sub-headings of the drainage report are as follows:

INTRODUCTION.

The Sacramento and San Joaquin Valley Floods.

CHAPTER I.

CHAPTER II.

PART III.

THE FLOW OF MINING DETRITUS.

All the general data thus far collected, concerning the extent, nature, and effect of the flow of mining debris, will be given under this head, with some suggestions (as much in detail as can be made at this time), for remedying the evil.

PART IV.

IRRIGATION OF THE PLAINS.

This part of the report will embody the general results of the irrigation inquiry, and will be suggestive of some legislation which I believe to be essential to the solution of the irrigation problem.

The special information gathered, which is statistical and descriptive in its nature, as reported by my assistants, will be appended under the following headings:

APPENDICES TO PART IV.

Irrigation in San Bernardino and Los Angeles Counties.
" " Kern County.
" " Tulare and Fresno Counties.
" " Fresno and Merced Counties.
" " Yolo County.

PART V.

PRESENT CONDITION OF THE INQUIRY.

What has been done thus far will be briefly reviewed, and what is yet necessary to be done in order that the full benefit may be derived from the work of the Department, and that some definite conclusions and plans may be laid down, will be set forth in this concluding part of the report.

HISTORY OF THE OPERATIONS OF THE DEPARTMENT.

Office of State Engineer,
Sacramento, January 10th, 1880.

To the Honorable the Senate and the Assembly of the State of California:

Before submitting a history of the operations conducted under my direction, I lay before you an outline of the nature and objects of the duties assigned to this department.

OBJECTS AND WORK OF THE STATE ENGINEER DEPARTMENT.

The object of this work, as held in view during its progress thus far under the instructions contained in the law, have been as follows:

First—The solution of the problems of drainage presented in the great valleys of the State, so that upon general plans thus formed all works undertaken for river improvements and reclamation of lands may form a part of one harmonious whole and thus contribute

towards the final accomplishment of the ultimate object—the prevention of widespread inundations and the improvement of the navigation of the rivers.

Second—The solution of the "debris problem," so called, in order that means may be suggested whereby agricultural lands shall be protected from the flow of mining detritus, and that the rivers through the valleys be relieved from the burden of sediment which is now brought into them by the streams from the mining regions, without radical interference with mining interests.

Third—The solution of the irrigation problems, in order that the greatest good may accrue to the greatest number of citizens through the use of the waters of the streams of the State in irrigation.

THE PROBLEM OF DRAINAGE.

To perfect the rapid drainage of a valley is to prevent the uncontrolled inundation of its plains. Nature rarely presents a highly fertile land whose drainage is other than very defective. A perfect system of drainage is as much a work of art as is an unobjectionable system of sewerage in a large city.

Sewerage works are constructed in the infancy of great towns without system, without art. Long afterwards, when as the result of defective sewerage works, death and disaster have reaped an undue harvest, a struggle is made for systemization.

So, in the early settlement of every valley, the interdependence of works affecting its drainage is overlooked as much as the intimate relations of the parts of a sewerage system at first is.

The farmer who builds a levee along the river in front of his property, fails to see the effect which that particular embankment may have upon the general system of drainage in this valley, as the city property owner, who in early times constructed a large wooden sewer on a steep grade, to enter a small pipe sewer on a gentle slope, failed to perceive how that work might affect others.

A levee on a river is but a side of a drain which forms a part of a system more complicated in its parts, subjected to more complex and far more powerful influences than any sewerage works can ever be.

Though all works necessary to effect the complete and rapid drainage of a great valley contribute directly to prevent overflow of its alluvial plains, there is always much to be done in accomplishing this end, which is not designed directly for the protection of any particular part of these lands; thus, while an embankment will possibly keep the water off from one piece of property, the removal of a bar in the river, or other rectification of the channel in front of that embankment, may so facilitate rapid drainage as to prevent the overflow of many tracts along the river, far above.

While the construction of a levee may not be essential to render the property immediately behind it cultivable, because the waters which escape at that point run away quickly, the absence of that embankment may render thousands of acres, situated far down the valley, desolate and unproductive, because of the lodgment and long resting of the floods therein, which escape from the channel where the levee was wanting, far above.

While facilitating rapid drainage in one part of a river may be a a great relief to lands above, the immediate result may be an overthrow of protective works on the lower river.

While the efficiency of all natural drains may be greatly enhanced, a partial treatment of them may produce disaster.

In order that this subject may be so understood in all its parts and details with respect to the great valleys of this State, and that system may prevail, a thorough study of the whole field is essential.

In the treatment of a great natural drainage system the very essence of the work is in the diagnosis of the case.

When causes and effect are thoroughly understood, the remedies are simple enough. As the physician who from long acquaintance understands the constitution of his patient, and knowing where to suspect and look for the seat of disease, quickly detects its locus and nature and then applies the remedy, so the engineer who has opportunity of feeling the pulse and studying the parts of a great drainage system, learns of its defects and can shape a treatment for their correction.

Because there is so seldom a study made of these matters, as a whole, because engineers are called upon to give opinions and design works, without the data to guide them, the long personal acquaintance with the phenomena of the field in which they are called upon to act, and the scope of power to fortify their positions in dealing with the great forces of nature whose ravages they are expected to ward off, we hear of failure.

Now the works designed for the prevention of overflow in this State generally have failed. Millions of dollars have been expended and lost in endeavoring to protect property from inundation.

The State sold swamp lands on condition that they should be reclaimed. In so doing she set up the owner of one swamp tract against the owner of another; for they both could not succeed without system and harmonious action amongst them all.

They have tried to become harmonized, they have endeavored to extend the scope of operations and achieve general success, but they have thus far failed.

Not only have the owners of swamp lands been disappointed in endeavoring to prevent inundations of their fields, but now tracts which were formerly above overflow, which were purchased and settled upon as free from flooding, have become, and others are rapidly becoming subject to annual submersion; and this, in a measure, at least, because of the effects of works constructed for the reclamation of lands sold by the State to be reclaimed.

Through the medium of the Engineer Department, the State has undertaken to collect the data necessary and shape the works designed to accomplish the desired end of rapid drainage, and it has been my aim to so study the problems involved, as to place their solution upon the highest plane.

With this regard, the extent and location of lands subject to overflow, their characteristics with respect to topographical configuration, and soil and subsoil composition, have been inquired into.

The nature of the floods which submerge them in their several quarters, the manner in which the flood-wave is presented, the volume of discharge from the several sources of supply and the resultant of the combination of those volumes in the march of the wave down the valley, have been observed and studied.

The natural capacity of the channels of drainage, relative or comparative capacity in their several divisions, the effects of artificial constructions in increasing or diminishing in the capacity, have been ascertained as far as time and opportunity have permitted.

In doing this, and as a basis for all future study and planning detailed instrumental surveys of the rivers, and the adjacent lands at governing points of topography, has been made over nearly the whole field. Upon these surveys, as a basis—with the alignment, and the size, and the grade of the channels known—the march of the floods has been observed and their volume measured by the most approved methods, at many points.

Now, there are very many obscure influences which effect results over such a wide field as this. Phenomena which escape detection on the first study, may materially change results. Hence the importance of carefully verifying all work—duplicating the study, as it were; and such duty has added greatly to the labors thus far performed, and still demands attention.

THE DEBRIS PROBLEM.

The bearings of this question are too generally understood to necessitate an elucidation of them here. Suffice it to say, that the law requires the State Engineer:

1. Inquire into the question of the flow of debris from the mines into the watercourses of the State.
2. Ascertain "the relation which hydraulic mining bears to the navigation of rivers and their carrying capacity."
3. Ascertain the extent of actual and threatened damage to agricultural lands from the debris deposit.
4. "Devise a plan whereby injuries caused by the flow of detritus into the streams can be averted without interfering with the working of the mines."

THE PROBLEMS OF IRRIGATION.

Irrigation, as a process, is just the reverse of drainage.

The mere application of water to land in any one instance is a very simple operation in agriculture.

The engineering works necessary to divert water from a stream, conduct it to lands, and spread it thereon, are in themselves generally simple constructions. But the agricultural methods and the engineering devices employed in irrigation, under different circumstances, are many and varied; and each new locality presents some peculiar characteristic of topographical shape, geological formation, or climatic influence, which may render one or the other of the simple methods or devices in irrigation more applicable than its fellows.

Not only are the material differences in the plans of preparation for irrigation, on account of the shape, soil composition, etc., in the lands to be watered in each instance, but the character of the crop to be cultivated frequently makes necessary a special disposition of the field, and a peculiar arrangement of works in applying the water; so that in the same locality a great variety may exist in the manipulations and periods of irrigation. And still again, the influence of irrigation on soils is such, that after the first few years of its practice at a new locality, it may be necessary to change the methods of preparing the lands, in order to effect the economical and rapid distribution of the waters.

Now, all these variations in soil, in crops, and in methods of application of water, produce corresponding variations in the amount of

water needed, and the periods when it is required to effect the irrigation; so much so, that under extreme circumstances the quantity of water flowing throughout the season, which in one instance will irrigate 600 or 800 acres, in another will only effect the watering of 20 acres. With all these varying circumstances affecting the measure of good which may be derived from the use of water from any source for the purposes of irrigation, it may well be understood that much depends upon the careful adjustment of methods suitable in each instance, and upon watchful management in distributing water, if anything like the full duty is to be obtained from the quantity used.

In new countries, when irrigation is first introduced, the cultivators are not skilled irrigators. As time goes on, they gather some practical knowledge by their own experience, but in each instance such experience is limited to a very small scope. They fall into error, into habits of extravagant use of water, and do not progress in an understanding of irrigation as rapidly as they should. It is only from a comprehensive viewing of the practice—an extended study in detail, with notation of the varied circumstances as they occur—that a just conclusion may be arrived at as to the best methods and means to insure the greatest good from the water used. Viewed thus, irrigation is an art, and one exceedingly intricate in the modifications of its practice. But it is an art very much abused, and debased to the level of a mere process in agriculture, too often only to suit the prejudices of those practising it. The instance is not on record where the cultivators by irrigation, over any considerable area of country, have ever voluntarily brought the use of water to near its highest standard, and thereby reaped the greatest possible measure of good from it.

Even in the older countries where irrigation has been practiced for centuries, it is only by continued vigilance and the exercise of the most stringent regulations that very great waste is prevented.

Water is the precious element wherever irrigation is necessary. In the use of water, every cultivator becomes the opponent of all others. If each could have all he desired, and whenever he wanted it, the case would be different; but where this could be, irrigation is not a necessity. The water supply for irrigation is itself exceedingly variable, both as regards different localities and in each locality—according to the character of the season and the time of the year. All the old world experience shows, and moreover the report which is to follow will add testimony to the conclusion, that differences with respect to the distribution and use of water from the natural streams are not settled amicably amongst the claimants, to the best interest of the whole community. It is to the interest of the State that the water from her streams should be used to advantage, that the greatest good may be wrought by its application. And not only is there this apparent interest which every one will acknowledge, to be subserved, but there is an immediate and pressing necessity for quieting the strife which now exists between claimants of water. By withholding such quarrels from the Courts and adjusting the matter of claims to water, confidence in the future welfare and prosperity of the irrigable regions will the sooner be established, and their development will be promoted, instead of hampered as it is at present.

The State, by throwing open the waters of her streams to appropriation, has directly laid the foundation for their wasteful and injudicious use and wrangling over their distribution from the natural

channels. There is no check whatever upon the appropriator. He makes a claim to water which the law permits him to divert, provided he pursues due diligence in so doing, and converts it to some useful purpose. But he is never required to prove up his claim, to show that he has complied with the law by diligently prosecuting those works necessary to make good faith, and by using the water; much less is there any recognized rule as to what constitutes due diligence; and still less is there any recognition as to what is an economical use of the water.

With the view of collecting and disseminating that knowledge which will enable irrigators to best profit by the use of the water, and with a view of obtaining those data which will enable the State to promote harmony amongst claimants of water, and ultimately enforce an economical use of that precious element, I have shaped the work of this Department.

With this regard, the quantity and time of presentation of water in each source of supply are observed, the character and extent of lands which are irrigable ascertained; the data respecting the practical results of irrigation collected and formulated, in order that it may be known how much water will effect the desired end, under the varied circumstances spoken of. The work hereafter mentioned has been conducted with the view to obtaining these last mentioned items of knowledge.

THE FIELD OF OBSERVATION.

The Sacramento Valley is annually the scene of widespread inundations of lands whose reclamation has been attempted; and almost every year very much property protected by levees is threatened with destruction. The lower portion of the San Joaquin Valley, though less frequently the recipient of floods which bring disaster, is still subject to them, and there still remain thousands of acres of land altogether unprotected from the waters.

These two valleys, joining at one outlet—their rivers having a common delta, and opening to the Bay—have afforded the problems of drainage to be studied, and the surveys and examinations for such purpose have been made therein.

The entire length of the San Joaquin Valley, from the Cosumnes River southeast to the Tejon Mountains, is 260 miles. In the lowest portion of the valley are many thousands of acres of land subject to inundation. Immediately alongside of this submersible plain lie two higher ones, in combined width varying from 30 to 60 miles, and extending throughout the San Joaquin, Tulare, and Kern Valleys, the dividing lines between which are almost indeterminable. These high plains require watering, and here has been the chief scene of the inquiry into the subject of irrigation.

The total length of the great valley, comprising the Sacramento, San Joaquin, Tulare, and Kern, is 410 miles, and its area is about 16,060 square miles, which is one-twelfth of the entire area of California; it is equal to one-half of the area of the State of Maine; it is greater than the area of Holland, and is equal to the area of the valley of the River Po, in Italy.

The area of Sacramento Valley, from Iron Cañon to the Cosumnes River, is about 4,769 miles.

The area of San Joaquin Valley, from the Tejon Mountains to the Cosumnes River, is about 11,290 square miles. The waters draining

off from 20,213 square miles of hilly and mountainous country are discharged into this great valley (made up by the San Joaquin, Tulare, and Kern Valleys) by a large number of tributaries.

The entire drainage area of the two rivers above their common outlet is therefore about 56,213 square miles. This area is greater than the combined areas of Maine, New Hampshire, and Vermont, and is greater than the areas of either New York, Pennsylvania, or Louisiana.

The most important of the perennial streams which discharge their waters into the Sacramento and San Joaquin, Tulare, and Kern Valleys, are seventeen in number. They may be enumerated as follows: Sacramento river at Iron Cañon, with a discharge varying from 4,000 cubic feet per second at low water, to about 160,000 cubic feet per second at extreme flood stages. Feather, Yuba, Bear, and American rivers, whose combined discharges vary from 3,100 cubic feet per second, to 200,000 cubic feet per second. Cosumnes, Mokelumne, Calaveras, Stanislaus, Tuolumne, Merced, Chowchilla, Fresno, San Joaquin, King's, Kaweah, and Kern Rivers, whose combined discharges range from about 2,200 to 250,000 cubic feet per second.

The large creeks are over twenty in number. To this class of streams belong: Putah, Cache, and Stony Creeks, which descend from the eastern slopes of the Coast Range mountains into the Sacramento Valley. The greatest discharge of these creeks is in the aggregate about 150,000 cubic feet per second for very short periods of time. Big Antelope, Mill, Deer, Chico, Butte, and Honcut Creeks, which enter Sacramento Valley from the east. Their greatest discharges combined are about 50,000 cubic feet per second. Littlejohn, Bear, Mariposa Creeks, Tule River, White River, and Posa, Caliente, and Tejon Creeks, which enter San Joaquin Valley from the east, possibly discharge as high an aggregate as 60,000. Las Uvas, San Emidio, Los Gatos, Cantua, Big and Little Panoche, Saucelitos, San Luis, Orestimba, and Del Puerto Creeks, which descend from the slope of the Tejon and Coast Range mountains. The total discharge of this class of creeks, which enter the San Joaquin Valley, when at flood stage, is about 100,000 cubic feet per second.

Besides the rivers and creeks enumerated, there are between twenty and thirty smaller creeks which discharge their waters into Sacramento Valley below Iron Cañon. Their greatest discharge is in the aggregate about 50,000 cubic feet per second.

Small creeks which enter the San Joaquin Valley are still more numerous, and their greatest discharge is about 60,000 cubic feet per second.

The field in which the practice of irrigation and the problems connected therewith have been studied, extends much further south than the limits of the great valley. It embraces in the vicinity of Los Angeles two valleys, across which flow the Los Angeles, San Gabriel, and Santa Ana Rivers.

One of these valleys lies between the Coast Range and Sierra Madre Mountains, and extends from San Fernando to San Bernardino; it has an area of 970 square miles.

The other is the coast valley, which lies between the Coast Range Mountains and the Pacific Ocean. The area of this valley is about 800 square miles. The mountain drainage area of the rivers which flow across these valleys is 1,963 square miles.

ORGANIZATION OF THE FORCE.

A study of these fields of observation is a work of great labor; only to become acquainted with the leading features of the questions which come up requires continuous observation by persons specially fitted to the duties.

It must be remembered that this work is not simply an ordinary survey, though plain surveying is done to obtain certain data as a basis for other observations.

This investigation is really a physical survey of the valleys of the State, necessitating a certain acquaintance with the mountain water-sheds and their streams which enter these valleys. The hydrology of the country is then a subject of special study, involving not only the flow of water in the streams, its quantity and manner of presentation from the mountains, and progress down the valleys, but the transportation of sediment by the water and the effects thereof on channels and lands.

The soil-composition of the lands requiring irrigation, the adaptability of soils to irrigation, and the effect of water upon them, as affecting the quantity of water required for this cultivation by wet farming, are studies undertaken.

This class of duty is not common. Though doubtless there are many able gentlemen acquainted with the theory of each division of this class of work, but few have had experience, simply because opportunities but seldom offer.

Hence, in commencing this duty there was very much to be learned by those employed in its several branches, and unavoidable delays were experienced in bringing about an organization and efficient condition of the force.

This was particularly the case with respect to the hydrographic parties—those engaged in gauging the streams—in which labor the most modern and improved methods and appliances were adapted to the peculiar conditions here found.

The work of organization was commenced in May, 1878, but regular field work was not commenced until near two months afterwards.

The greater portion of the field work has been done by four parties, designated as follows:

1. The sounding and gauging party.
2. The irrigation surveying party.
3. The river surveying party.
4. The debris surveying party.

These parties were organized, placed in the field, and did duty as hereafter described.

Each Assistant Engineer in charge of work, whether in the field or in the office, has been required to keep a Journal of work and to make written monthly reports of operations in detail, so that a complete record of observations is to be seen in this office. Under these circumstances it is scarcely necessary to do more here than give an outline of operations, for a full history would necessitate the recital of many unimportant facts and the repetition of tedious details.

Party No. 1.

The Hydrographic and Hydrometric Party.

This was organized as a boating party. In numbers of members it ranged from five to fourteen—according to the duty being performed. Its full membership was as follows:

One assistant engineer in charge.
One computer and draughtsman.
Two observers of current meters.
One recorder of soundings.
One captain of the launch.
One engineer of the launch.
One leveller.
One rodman.
One tidal observer.
Four boatmen.
One cook.

The party was quartered in a floating house, which was moved from point to point as convenience to the field of duty required.

A steam launch and four row boats, with quite a complete apparatus for current measurements and other observations, besides those for ordinary surveying operations, made up the working outfit of this party. This outfit, including the quarter-boat or ark, cost nearly $5,000.

The work of gauging and sounding the larger streams was performed by this party. Its duty fairly commenced in June, 1878, when, organized as a small boating party, of an Assistant Engineer, three boatman, and a cook, the work of placing and rating tide gauges was commenced and followed by placing river rod gauges and rating current meters preparatory to gauging operations.

During July, August, September, and a part of October, 1878, special gauging surveys were made on the Sacramento River at Colusa, Butte Slough, Knight's Landing, mouth of Feather River, and mouth of American River, including the Sacramento City water front; and the river was gauged one or more times at each of these points.

During the early portion of the month of November the current meters were re-rated at Sacramento, and experimental observations made, preparatory to the work during the approaching high water period.

After which, and until near the last of December, this party was engaged in making a topographical survey of Sacramento River from the Knights Landing special survey to the mouth of Feather River special survey. This is an exceedingly bad portion of the river, and it was carefully surveyed in alignment, and measured by numerous cross sections.

The Sacramento River was then sounded from Feather River to Sacramento; and special examination made of "Six-mile" and "Ten-mile" bars, together with levelling on each side of the river, to ascertain slope of bank lands, occupied this force until January 8th, 1879.

The American River was then surveyed and cross-sectioned up from the Sacramento to a point where it is within high banks, about nine

miles from the mouth. This duty, together with preparations for gauging on the river between Knight's Landing and Sacramento, consumed the time to the commencement of the high water freshets in February.

Throughout February, March, and until the middle of April, the party in full force was occupied in gauging and sounding at points on the river between the head of Grand Island and Butte City. For a portion of the time the force was divided into two gauging parties, and an extra steam tug was employed to facilitate work.

After the freshet had run down in April, the party was somewhat reduced in numbers, and was occupied in making a topographical survey, with numerous cross-sectional measurements of the Sacramento River and adjacent lands, from Butte City to Knight's Landing, which work was completed in about a month.

During May and the early part of June, re-sounding and gauging operations were conducted at special points on the Sacramento; and thence the party was moved around into the San Joaquin, expecting to have the opportunity of there observing a material freshet from the melting snows, but none such occurred.

Some observations were made, however, but the results are by no means satisfactory, owing to the failure of the water and the limited time available to arrange gauges, etc.

In July final observations were made for the purpose of testing the current meters, and the party was disbanded.

Party No. 2.

Irrigation Surveying Party.

The party was organized as a wagon party. Its full membership was ten individuals, as follows:

One assistant engineer in charge.
One transitman.
One leveler.
One rodman.
Two chainman.
One flagman.
Two teamsters.
One cook.

The transportation equipment, when complete, consisted of:

One four-horse camp wagon.
One two-horse thoroughbrace.
One two-horse buckboard.

Tents were used for housing, and other outfit to suit, with instruments and miscellaneous apparatus according to the duty.

The work of surveying and gauging most of the principal rivers depended upon as sources of water supply for purposes of irrigation, examining canal routes, making topographical studies of the plains, gauging and reconnoitering irrigating canals, and collecting miscellaneous data concerning the practice of irrigation in Tulare and Fresno Counties, was intrusted to this party.

Field work was commenced early in July. A survey of King's River was made much in detail, from the point where it leaves the mountains to the swamps adjacent to Tulare Lake.

Grade lines were run south from King's River to the Kaweah

River, to the White River, and to the southern limit of Tulare County, with long cross-sectional lines over the plains, to ascertain detail of topography with respect to slope.

The King's, San Joaquin, Fresno, Chowchilla, Mariposa, Merced, Kaweah, and Tule Rivers were surveyed for gauging, and gauged at several points, each in a number of instances more than once, and in the case of the King's and San Joaquin, three or four times at a place.

Level reconnoisances were made from the King's River north to the Stanislaus River, with the view of ascertaining the routes upon which accurate surveys may be made in the future for canal grade lines out from the rivers.

Altogether this party made 18 gauging surveys of rivers and creeks, and 21 of canals; ran 270 miles of transit line, with topographical and cross sectional work; and 655 miles of levelling; besides gauging observations, reconnoisances, and miscellaneous duty.

The force was reduced from time to time until the party, brought down to four members only, was disbanded in August, 1879.

Party No. 3.

The River Surveying Party.

This party was organized as a boating party. In number of members it ranged from eight to ten individuals. Its full membership was as follows:

One assistant in charge, and transitman.
One topographer and draughtsman.
One leveller.
Two rodmen.
Two chainmen.
Two boatmen.
One cook.

The party had quarters similar to those of Party No. 1, and was provided with an outfit of small boats, instruments, and miscellaneous apparatus.

The work of surveying and cross-sectioning the larger rivers was, for the most part, done by this force.

Field work was commenced on June 25th, 1878, on the San Joaquin River, at the head of Old River. Between that time and October 25th, all of the channels of the San Joaquin River below the mouth of the Stanislaus River, including the Main River, Old River, Middle River, and Burns' Cut-off, as well as the Stockton channel, were accurately aligned and cross-sectioned at many points, level determinations made, and topography noted.

The total mileage made was about 170 miles, at times through almost impenetrable willow thickets or marshes scarcely to be waded across.

Thence on to the 18th of November this party was occupied in a similar survey on the lower Sacramento River, including Old River, and the total length of channels thus surveyed was about 36 miles.

On November 25th the work was commenced on the Feather River, about eight miles above the mouth of the Yuba, and carried on down to the mouth of the Feather, embracing not only a survey and cross-sectioning of the river itself, but a topographical examination of

much of the adjoining country. Total length of line run on this survey, 63 miles.

Party No. 3 returned to Sacramento, and was disbanded on January 6th, 1879.

Party No. 4.

The "Debris" Surveying Party.

This was organized as a wagon party. Its membership consisted of from three to eight individuals, including an Assistant Engineer in charge as transitman, a leveller, rodman, chainman, teamster, and cook. Its transportation outfit, when complete, was two thorough-brace wagons, drawn by two horses each, and the members were housed in tents, which, with camp and surveying implements, completed the outfit.

As its name implies, the field of duty occupied by this party was, for the most part, along the rivers which bring down mining detritus. Levelling from the mouth of Feather to a point 6 miles above Oroville, from the Feather, at Burt's Ferry, to the Sacramento, at Butte City, up the Sacramento to Colby's Ferry, and to Nord on the railroad, down the Sacramento to Meridian, was done by this party.

A survey of the Yuba River, involving the running of several lines with levels on both sides of it, from its mouth to Smartsville, in the cañon of the foothills; continuations of that survey up the cañons to the points where the detritus is deposited, to a total distance within the mountains of 66 miles, was made by this party, as also a similar survey of the Bear River, from its mouth to a point well within the foothills.

Gauging surveys were made of the Cosumnes, American, Bear, Yuba, and Feather Rivers, and intermediate streams, as well as of the creeks northward to Chico Creek. Similar surveys were made on the Sacramento, at Tehama, and at the Iron Cañon, above Red Bluffs, of Stony Creek, and of all tributaries to the Sacramento north of Stony and Chico Creeks.

All of the principal streams were observed to some extent, and account kept of their rising and falling stages during the season. Water samples were taken throughout the year at various points on the several streams, and special examinations were made of mining property in some cases.

In all, this party made 20 gauging surveys; ran 207 miles of transit line; and 474 miles of level line.

The field party was finally disbanded in October, 1879, after having been reduced several times to only three members.

The very many special examinations made by this party, in the nature of looking into the facts of the debris matters, consumed much time, the result of which cannot be accounted for in miles of line or number of surveys made.

OTHER FIELD WORK.

In addition to the regular surveys and examinations made by the four parties enumerated, there were at times several other small parties in the field.

An office assistant was frequently detached with two or three men to run check levels between points throughout the valley; and such

duty occupied a small party for several months in all during the summer of 1879.

During the fall of 1879 two small parties were detailed for special examination in the mining region, one making certain reconnoisances and surveys in Butte County, and another operating in El Dorado and Placer Counties; in all occupying about two and a half months.

IRRIGATION EXAMINATION.

Kern, Los Angeles, San Bernardino, and Yolo.

In addition to the surveys and examinations made by Party No. 2 in Tulare, Fresno, and Merced Counties, an assistant was detailed in January, 1879, to collect data and make special surveys for information on the irrigation subject in the counties above named.

This labor occupied the time until October, 1879, during which a very thorough study was made of the several systems of irrigation, as the result of which there are the reports upon irrigation in the counties named appended to Part IV of this report, and work done as per the following

SYNOPSIS OF FIELD-WORK.

Party No. 5.

Kern County.—Miles of transit lines with levels, 23.3; miles of levels without transit, 13.1; number of rivers gauged, 1; number of river cross-sections, 14; number of canals gauged, 24; total length of canals examined, in miles, 275; number of canal cross-sections, 140.

Los Angeles and San Bernardino.—Number of streams gauged once, 15; number of canals and ditches gauged, 66; number of canals and ditches examined, 125; number of canal and ditch cross-sections, 138.

Fresno, Merced and Stanislaus.—Number of canals gauged, 2; number of canal cross-sections taken, 20; total length of canals examined, in miles, 100.

Yolo.—Number of canals examined, 6.

Very good maps of the San Bernardino and Los Angeles regions were secured from the best available data and are now in this office.

SYNOPSIS OF ALL FIELD-WORK.

Total number of miles of—	
Transit line	1,006
Level line	1,669
Channel surveyed topographically	532
Total number of cross-sections—	
Of rivers	989
Of canals	566
Total number of gauging surveys—	
Of rivers	65
Of canals	243
Total number of gaugings made—	
Of rivers	91
Of canals	243
Total number of gauges set—	
Tide gauges—self-registering	6
River rods	127
Canal rods	52
Total number of reconnoisances—	
Of rivers	15
Of canals	6

OFFICE WORK.

The office work of this Department has been arduous, and frequently perplexing. The extreme difficulty of connecting work with other surveys, for the purpose of compilation, has been a fruitful source of trouble.

The current and flood computations have been complicated, the tabling of surveyed lines and reduction of levels very tedious, and the mapping oftentimes extended and laborious.

The study of the loss of water in canals and rivers in the irrigation regions has involved a great amount of tabulation and reduction from the results of special gauging observations; and the general arrangement of data has occupied much time.

I submit the following tabular statement of the work done in the office as per one man:

SUMMARY OF WORK DONE IN OFFICE OF STATE ENGINEER.

Description of Work.	Time in Months.
Tabling of lines	$12\frac{3}{4}$
Reduction of levels, tidal and river computations, preparation of profile, etc	$19\frac{3}{4}$
Preliminary mapping	$26\frac{3}{4}$
Final mapping	$25\frac{3}{4}$
Work on river water samples—classification of debris	$5\frac{1}{4}$
Preparation of reports	$16\frac{1}{2}$
Gauging reductions—studies of river discharges—comparison of results, etc.	12
Miscellaneous	$5\frac{1}{4}$
10 years, 4 months	124

TOPOGRAPHICAL SURVEYS.

The surveys of the rivers, streams, and canals have all been made with the view of obtaining the detail of topography, with respect to their channels and banks, and that of the adjacent lands.

In addition to the ordinary transit surveys for alignment of the works and channels, levellings were made in the most careful manner, and checked, in some instances, for many miles, the third and fourth times.

For most of the streams, the lines of survey were platted immediately in the field, on a large scale, by a draughtsman, and the details of topography drawn in at once from offset measurements and angular bearings, thus insuring great accuracy and dispatch in securing details.

GAUGING SURVEYS.

The gauging surveys heretofore spoken of, were made on the larger rivers with the view of obtaining most accurate measurements of the river channel, so that the current measurements and other observations made to determine the slope of the water surface, would afford data for a close study of the flood phenomena and estimates of volume of discharge from the current meter results. On the upper rivers the current meters were not used neither, on the smaller streams and canals, but float observations were relied on, and in some instances the discharges were calculated by the accepted formulæ of Kutter,

from the observed water slopes and cross-sectional measurements. Here then the gauging surveys were necessarily made extended and accurate also. Some of these special surveys on the larger streams embraced several miles of channel-way, with cross-sections 400 feet apart. Others embraced only a mile to two miles, with cross-sections at less distance, and still others embraced not over half a mile of channel with cross-sections every 200 feet. On the smaller streams and canals general length of gauging surveys was from 600 to 1200 feet.

HYDROGRAPHICAL WORK.

Another object of the gauging surveys was to afford the basis for a study of the movement of the channel bottoms in the larger streams, where the sand-flow is brought down. At such points repeated re-sounding over the same lines—originally laid out—has afforded the data desired in this study. As, for instance, at Freeport, where some lines were sounded over 14 times, and at Sacramento, where some were sounded over 12 times, extending through a period of a year. This hydrographical work has been most extensively prosecuted on the Sacramento River, and there is now a most excellent basis laid for studying the hydrography of that stream for all future time. In this connection the results of work done under the direction of Col. G. H. Mendell, acting for the General Government, have been secured in exchange for results of the State survey, and have been of material assistance and great value to this Department. The topographical and hydrographical surveys of the Sacramento River are now complete, and all done in the future will be to re-examine the channel to ascertain what change has taken place. This is not so of the San Joaquin, however, where the hydrographical work is yet in a great measure to be done, and the surveys to be extended through from the Stanislaus to the upper limit of flooding.

TIDE GAUGES AND GUAGE RODS.

For the purpose of tracing the tidal curves during low water stages, as well as the rise and fall of the floods when the streams are high, clock-work tide gauges and plain gauge rods were employed.

Of the former, six were ordered made, after a simple design, and have done good service on the Sacramento River. These instruments preserve a continuous register of the movement of the water surface, by marking with a pencil upon a traveling sheet of paper the elevation or depression as it occurs, according to a scale of one-twelfth.

The rods were used in great number, there being upwards of 180 of them put up throughout the valleys. Volunteer observers were generally found who kept very fair records of the fluctuations of the water's surface when most needed.

Of course all rods and gauges are connected by levelling, so that the relative elevation of the water's surface at any point above low tide in the bay, and the slope from point to point, is told from the results of the observed heights.

CURRENT OBSERVATIONS.

Current observations were made in the principal gaugings by means of electric-report current meters of the most approved pattern,

of which four were made to order for the Department, and two were borrowed from the United States Engineer at San Francisco.

It is believed that the use of these instruments gave the best results which could have been had. The utmost pains were taken to secure reliable work, often under most unfavorable circumstances and with vexatious mishaps inseparable from the operation of gauging any great river when in flood, but which develop wonderfully on the Sacramento owing to its being so heavily charged with sediment, driftwood and fine floating rubbish, and also to its exceedingly unstable bottom.

It is thought, however, that the work of gauging was more complete than any ever before accomplished in a stream of like size in flood, and I hope to have the opportunity to present its results in detail, when the more important generalities derived from them shall have been disposed of.

SEDIMENT OBSERVATIONS.

To secure samples of water from the surface of a stream, it simply requires a dipper, but to get a fair sample from beneath the surface, particularly near the bottom of a river twenty-five or thirty feet deep, with a current of five feet per second, is a difficult matter.

Many devices have been tried for this purpose. It is believed, however, that those used by this Department are among the best, if not the very best.

One of the hydrophores is a horizontal nickel-plated cylinder, with revolving sliding trap-door ends, held in a square metal frame, mounted on a heavy plate.

The cylinder with its trap ends, when closed, is removable from the frame for purposes of discharging its charge, which is the twentieth part of a cubic foot in bulk.

This apparatus, with the doors set open, is lowered by means of cords, to any desired depth in the water, in such a position that the flow of the current is straight through the cylinder, and at the desired moment the doors are made to close by means of a pull upon a wire setting loose the trigger to the spring, which is arranged for the purpose, and thus a fair sample of the water, just as it runs at any point, may be obtained.

From these samples, by means of evaporation or filtration of the liquid, the quantity of solid matter held by the water is determined, and thus is obtained the data upon which important points involved in the debris question are discussed.

EXAMINATIONS OF MINES.

In order to gather some data concerning the nature and amount of material put into the streams by the hydraulic mining process, special reconnoissances were made of many excavations—the material in the banks was examined, and the size of the excavations was measured in many cases where it was possible to get the account of the amount of water used in effecting the washing. Thus some reliable data has been obtained concerning the bulk of material which, under each of the varying circumstances presented, is washed out by the miners' twenty-four-hour inch of water, the standard of measure throughout the mines. Some observations of this kind had

been occasionally made by mining engineers, but generally the data was very meager. Even yet it cannot be said that sufficient observations have been made to make anything more than approximate estimates; for the circumstances are so very different in each mine, that there must be an ever varying duty of the water.

However, knowing something of what a given quantity of water will effect, it becomes possible to estimate on the quantity of material put into the cañons, by ascertaining the amount of water used. This has been done through the courtesy of many water companies who have supplied statements of their distribution of water. This class of data has been obtained quite complete from all of the principal companies north of the Cosumnes basin to the Feather basin, except in Plumas and Sierra Counties.

FIELD DUTY.

The duty of field parties of this department has been at times exceedingly arduous, not to say hazardous.

The heat of the plains and swamps of Fresno, Tulare, and Kern Counties tells heavily upon men who cannot choose their hours for traveling, and the exposure in the wet and mud of the river and canal surveys in that locality, brought on sickness amongst the members of Parties Nos. 2 and 5, and consequently delayed the work.

Fully as trying was the experience of the members of Parties Numbers 1, 3, and 4, along the rivers and in the swamps of the San Joaquin and Sacramento Valleys. On one occasion nearly every member of Party Number 1 was stricken with malarial fever.

Again, the exposure of the members of the same party during the period of gauging throughout the storms and floods of winter constituted severe duty, not unmingled with its dangers, for the risks were such that almost any day might have seen the drowning of a boat's crew.

The survey of the Yuba River Cañon by Party Number 4 was also a duty unmixed with pleasure, and the hardships and dangers of which should be encountered to be appreciated.

EMPLOYÉS OF THE DEPARTMENT.

It gives me pleasure to refer to the valuable service rendered the State by the many able employés of this Department, though I only mention those who were in charge of some branch of the work.

Mr. Jas. D. Schuyler, Assistant in charge of Party 5—Irrigation Investigation.

Mr. M. Manson, Assistant in charge of Party 4—Debris Investigation.

Mr. C. H. Kluegel, Assistant in charge of Party 3—Topographical Surveys.

Mr. A. G. Warfield, Assistant in charge of Party 2—Irrigation Survey.

Mr. A. Boschke, Assistant in charge of party 1—Hydrometric Field work.

Mr. Edward Yorke, Assistant in charge of general office work.

Mr. C. E. Grunsky, Assistant in charge of Hydrometrical work—Office Reduction.

Mr. D. D. Griffiths, Assistant in charge of check levelling work.
Mr. W. M. Fitzhugh, Assistant in charge of Party 4—River Surveys.

JOINT SURVEYS.

The Sacramento River Drainage Commissioners made certain surveys, which have been availed of for purposes of this Department, seeing that they were made in harmony with those being made under my direction.

The United States, through Col. G. H. Mendell, made a thorough survey of the Sacramento, below the American, in the Fall of 1878, and this work was connected with the land hydrographic work done by this Department, and by the surveys of the Drainage Commission—thus adding greatly to the store of information.

The Coast Survey has made a re-survey of the lower division of the river below Collinsville, and of the Suisun and San Pablo Bays, and the results of this work have been received for study.

The survey of the Yuba River cañon was participated in by Mr. A. W. Von Schmidt, C. E. for the Miners' Association, and by Mr. G. F. Allardt, C. E. acting for the City of Marysville. Each of these interests contributed towards the expense of this work, as per the statement to be made by the Secretary, and which will be embodied in Part V of this report.

ACKNOWLEDGMENTS.

This Department has been the recipient of many favors and much courteous action on the part of those who may never reap any benefit whatever from its workings.

Many persons who have kept record of the fluctuations of the river where rods were placed, others who have been at pains to collect and forward to the office information of interest and value, deserve thanks and mention by name, if such allusion would be any recompense; but, unfortunately, the list would be too long, and the data is not at hand to make it complete, so I forego further remarks for the present.

Especially, though, should acknowledgment be made to the officers of the water-ditch companies who have furnished memoranda of workings of their property, and to the Chiefs of the Engineering Department of the Central and Southern Pacific Railroad Companies, who have placed much valuable engineering data at my disposal.

To officers of the United States Engineer Corps stationed at San Francisco, who have favored the State with the privilege of using certain instruments, as well as in other matters, and to some officers of the Coast Survey, both in San Francisco and at Washington, for courtesies extended, the acknowledgments of this Department are due.

THE CONSULTING ENGINEER.

In December, 1878, Gen. B. S. Alexander, appointed by the Governor as Consulting Engineer, died. In him the engineering profession lost one of its masters, the State Engineer was deprived of an able and most agreeable counsellor, and from the State was taken one who had seen most, thought much, and to a purpose, of the field in which this Department is called upon to act.

I have had the benefit of consultation to great advantage with

Col. G. H. Mendell, also appointed by the Governor as Consulting Engineer. We have traveled over much of the field of operations together, and together became acquainted with the very many important details, to be appreciated only when seen and studied on the ground.

SECRETARY.

Nor can I close without acknowledging the courteous co-operation which my efforts received at the hands of Gen. G. B. Cosby, appointed by the Governor as Secretary in this Department, and whose statements will appear in the concluding part of this report.

Very respectfully your obedient servant.

WM. HAM. HALL,
State Engineer.

REPORT

OF THE

STATE ENGINEER

TO THE

Legislature of the State of California--Session of 1880.

Part II.

SACRAMENTO:

STATE OFFICE : : : : J. D. YOUNG, SUPT. STATE PRINTING.

1880.

DRAINAGE OF THE VALLEYS

AND

THE IMPROVEMENT OF THE NAVIGATION OF RIVERS

LETTER OF TRANSMITTAL.

SACRAMENTO, California, January 21st, 1880.

Hon. John Mansfield, President of the Senate, State of California:

SIR: I herewith submit Parts I and II of my official report to the Legislature, being a report on the "History of operations" conducted under my charge, and a report on the "Drainage of the valleys, and relief of rivers when in flood," referring particularly to the Sacramento Valley drainage, with an incidental treatment of the debris problem, and also to the drainage of the San Joaquin Valley, and the improvement of the navigation of the San Joaquin River.

Accompanying you will find a letter introductory to the entire report, and addressed to the Legislature.

I also transmit a communication from Col. G. H. Mendell, consulting Engineer.

Very respectfully,
Your obedient servant,
WM. HAM. HALL,
State Engineer.

INDORSEMENT OF CONSULTING ENGINEER.

SACRAMENTO, California, January 21st, 1880.

To the Legislature of the State of California:

I have been, throughout the history of the State Engineer Department, familiar with the character and scope of its field operations. I have also read the report of the State Engineer, so far as it has been prepared, and have consulted and agreed with him in regard to its main propositions.

When the remaining chapters of the report shall be completed, I expect to submit my views upon the general subject.

I am, very respectfully,
Your obedient servant,
G. H. MENDELL,
Consulting Engineer.

REPORT.

INTRODUCTION.

Office of the State Engineer,
Sacramento, January 10th, 1880.

To the Honorable the Senate and the Assembly of the State of California:

INUNDATIONS IN CALIFORNIA.

The submersible lands.

There are two valleys in California whose low lands have been and still in a great measure are subject to annual inundation. These are the Valleys of the Sacramento and the San Joaquin, the combined area of whose submersible lands situated north of Tulare Lake, excluding Tulare and Kern Valleys, may be stated at 2,750 square miles—a territory much larger than the State of Delaware.

The main drainage ways.

The Sacramento and San Joaquin Rivers are the great natural main drains of these valleys, respectively.

The Sacramento.

The Sacramento River brings down a formidable flood volume almost every year, inundates a large area of country, and seriously threatens with devastation several hundred thousands of acres of lands, now in a measure protected by levees.

The San Joaquin.

The San Joaquin is in correspondingly high flood only about once in four years, so that, as to frequency of danger of destructive flooding, the low lands of its valley are at an advantage over those of the Sacramento.

Comparative floodings.

Moreover, owing to causes to be hereafter discussed, the condition of affairs, with respect to actual and threatened inundations, is annually becoming more alarming in the Sacramento Valley; whereas, in the San Joaquin no such tendency is apparent—at least to a degree which at all compares with that in the northern valley. Thus the Sacramento Valley drainage problems appear to be the most important of those pressing for attention.

The opportunities had.

Since this Department was created there has been one fairly good season for flood observations in the Sacramento Valley, and these have

been made as narrated in Part I of this report. The San Joaquin River has not presented an ordinary high flood since the work of this Department was commenced, so that, although the groundwork for the study of this subject of drainage has been, in a great measure, laid in the San Joaquin Valley, I have not been able to secure the data concerning flood phenomena which are necessary for the discussion of this particular subject in that valley.

Other scenes of inundation.

There are other important localities in the State which occasionally suffer from uncontrolled flood waters, and which, though less extended in area, are justly entitled to consideration and attention from this Department, in order that the data may be collected and formulated upon which some plans might be projected for their protection, but it has not been possible thus far for me to take up any but the most important subjects. Hence the report under this general heading now presented is devoted almost exclusively to the Sacramento Valley problems.

CHAPTER I.

THE SACRAMENTO VALLEY DRAINAGE.

TOPOGRAPHICAL DESCRIPTION.

The Great Valley.

The Valleys of the Sacramento, San Joaquin, Tulare, and Kern have been jointly called the Great Valley of California.

There is, in fact, but the one well-defined depression between the Sierra Nevada and Coast Ranges of mountains, so that it is difficult to draw the line of boundary between the adjacent portions severally named as above, and most of all is the line between the Sacramento and San Joaquin Valley hard to designate.

Boundary of the Sacramento Valley.

For the purposes of this report, the course of the Cosumnes River down to and as continued after joining the Mokelumne and the San Joaquin Rivers, to Suisun Bay, is adopted as a convenient and approximately correct boundary; and all of the territory lying northward therefrom, between the foothills of the Sierra Nevada on the east and those of the Coast Range of mountains on the west, is regarded as the Sacramento Valley.

Dimensions of the valley.

Its greatest dimensions on a straight line—that following nearly its longitudinal axis—is about 150 miles in a course S. 13° E. from the Iron Cañon to the mouth of the Mokelumne River, and its greatest width at right angles to this line is 50 miles. For 95 miles of its length, from the southern boundary, it maintains a width of 40 to 50 miles, and thence narrows down to a point at its northern extremity.

Area of the valley.

The region thus bounded is about 4,769 square miles in area. The lands may be classified as shown in the following table, wherein the areas given are of course only approximately correct, though compiled with care from the best topographical information to be had at this time:

Classification of the lands of the valley, as naturally constituted.

Designation.	Area in Square Miles.
High hill lands—Marysville Buttes	55.50
Low hill or rolling lands, adjacent to the foothills of the mountains	650.00
Dry plains, above reach of all overflow	2,321.45
Dry plains, subject to occasional temporary overflow from the tributary streams	450.00
Lands covered by debris and subject to flooding; river bottom or marginal lands naturally subject to temporary shallow annual overflow; low basin lands, not tule swamp, naturally subject to deep annual flooding; low basin lands, tule swamps, naturally subject to protracted deep annual flooding; island swamp lands and other tule swamps, naturally subject to flooding by high tides	1,254.00
River, slough, and channel surface of perennial streams	38.05
Total	4,769.00

Drainage of the plains.

Of the pluvial waters which fall in the valley of the Sacramento, it may be said that in all, except seasons of extraordinary heavy rainfall, such as have occurred about once every ten years since the settlement of the State, they are absorbed by the soil, and do not contribute materially to the swelling of the waves of flood in the main river and its tributaries.

Lands flooded in 1879.

During the high water of March, 1879, the low lands of the Sacramento Valley, to the extent of about 847 square miles, were covered with water; this area includes all flooded for a short period of time, as well as that upon which the water rested for several months. Above the mouth of Feather River, in what may be called the upper flood region, the area covered was about 483 square miles; and below that point, in what is called the lower flood region, the flooded area was about 364 square miles in extent.

Swamp and overflowed lands.

There has been listed to the State by the General Government about 549,540 acres of land in the Sacramento Valley as swamp and overflowed lands. It will be seen that although large areas of land were protected from flooding during the March freshet of 1879, yet the lands actually covered with water were greater in area than the total acreage listed by the General Government as swamp and overflowed lands.

THE MOUNTAIN WATERSHEDS.

Area and character.

The mountain watersheds whose drainage systems are tributary to the Sacramento, are in combined area more than two and one-half times the superficies of the valley itself. Subjected to violent rains during the winter and early spring, these mountain basins send down flood volumes of considerable magnitude at such times, and the melting of snows on the higher regions cause other waves of flood-water to flow down the principal streams during the later spring months.

The Sierra Nevada slope.

The eastern side of the Sacramento Valley is flanked by the Sierra Nevada Mountains, whose slope, drained by the American, Bear, Yuba, and Feather Rivers, Butte, Chico, Rock, Deer, Mill, and Antelope Creeks, with other smaller streams, has an area of 8,298 square miles; in elevation rises 7,000 to 11,000 feet above the sea, and receives, in seasons of ordinarily heavy rainfall, from 24 to 102 inches of the waters of precipitation in the form of rain and snow.

The Coast Range slope.

Upon the west the Coast Range slope, drained by Putah, Cache, Oat, Cortero, Willow, Stony, Thomes, Elder, Red Bank, and Reed's Creeks, with numerous smaller streams, into the valley of the Sacramento, is 3,075 square miles in area. This region is much less elevated than the face of the sierra east of the valley, is generally subjected to less downfall of waters, but receiving these for the most part in the form of rain upon surfaces from which it rapidly sheds, the volumes of flood are quickly accumulated and delivered upon the plain.

The Sacramento River mountain basin.

Northward, from the two great mountain slopes spoken of, extends the drainage basin of the main Sacramento, with those of the tributaries which enter before it comes out upon the plains, and is situated between the crest of the Sierra Nevada on the east and the summit of the ridge, which, with Mount Shasta for a central object, forms the divide just south of the Trinity River basin, whose waters find their way through the Coast Range to the sea.

Area and character of the basin.

This region, comprising the sub-basins of Cottonwood Creek, Clear Creek, McCloud River, Bear Creek, Canoe, Stillwater, Cow, Battle, and other creeks, includes the whole of Shasta and parts of Siskiyou Counties, and is 5,616 square miles in area. It is a mountainous and hilly region, with intervening comparatively small valleys and plains, and in elevation ranges from 1,000 to 14,000 feet above the sea. The rainfall is almost always in excess of that received in any portion of the great basin to the south of it, ranging from 30 to 110 inches per annum.

The Pit River basin.

In addition to this, the upper Pit River, above the boundary of Shasta and Lassen Counties—the principal tributary of the upper Sacramento coming through the mountains from the high plains and ridges of Lassen County and Siskiyou, east of the sierra—is a stream of considerable magnitude at times. The drainage area of this stream cannot be stated with any pretension to accuracy, but probably is about 2,950 square miles. This region is not subjected to such heavy rainfall as that previously described, and it is likely that flood-waters rarely come from the two at the same time.

THE STREAMS AND FLOOD-WATERS OF THE VALLEY.

The streams.

The streams which enter the Sacramento Valley are all torrential in character—that is to say, they are subject to sudden freshets of considerable magnitude, but generally of short duration, caused by the immediate and rapid drainage of a large portion of the waters of rainfall from their mountain watersheds.

Periods of full flow.

These freshets come at intervals generally of greater spaces of time than the duration of any one period of full flow. The occasions are exceedingly rare when all of the streams are in high flood at the same time, or even in consequence of the same storm; and, ordinarily, the waters of one freshet should be well out of the valley before those of another come into it.

Freshets in the sierra streams from the east.

The freshets of greatest magnitude in the Sierra Nevada streams, which enter the valley from the east (the Feather and the American), and which are the larger tributaries, succeed the falling of warm rains, after the mountains have become covered with snow, thus causing sudden thaws in the snow-fields. Such an event only happens after

the main stream through the valley has already been moderatel high several times during the season from the effects of rain storm brought down by some of its tributaries.

Freshets from the northern streams.

The freshets of greatest magnitude from the mountain basins o the Sacramento and the tributaries which also enter the valley nea its northern extremity, are produced by violent and sudden storms o rain, which ordinarily pass over the region of the tributaries farthe south, as cold rains of short duration and less violence.

The two sources of flood-water.

There are, then, in general terms, two sources of high water in th valleys drained, each composed of a group of streams which we mus expect to be in high flood simultaneously; and at the same time w must look for a moderate flood flow, in each instance, from th streams of the other group.

The ordinary high flood of the valley.

This combination of events produces what we may call the ordinar high flood wave of the lower valley—such as passes through th channel and over the low lands once, and perhaps twice, each winte or spring, except in seasons of drouth, occurring once or twice ever ten years.

The extraordinary high flood of the valley.

When, after several moderate storms during a season, there occur a violent and somewhat prolonged storm, or succession of rain storms immediately followed by a quiet and warm rain, the snows melt on the mountains, and great volumes of flood-waters enter the valley from all the surrounding watersheds at the same time, and thus are produced the extraordinary floods which have occurred periodically about once every ten years in the past.

The low land basins—Temporary reservoirs.

The river channels, and more particularly the Sacramento, as th main drain of the valley, being insufficient in capacity for the imme diate passage to the bay of ordinary floods, these waters have, for age past, poured over its banks and been temporarily lodged in the lov basins by which it is flanked for miles of its course, to be drained of after the passage of the flood-water proper.

The Sacramento as a water-carrying channel.

The river has always been one of poor regimen—great variation o capacity to pass the waves of flood through its different divisions— and its channel has always had serious local defects which have acte as obstructions to the passage of flood-waters. Thus, for 106 mile and more above the head of Butte Slough, there is a channel of *greate grade and greater dimensions than there is below*, all the way to th mouth of the Feather River, a distance of 64½ miles. And, again, th very shallow bars known as "Six-mile," "Haycock," "Hog's-back, "Iron House," and "Newtown" shoals, do not permit the free pa sage of the flood waves, as do the deeper and better formed reaches the channel above and below them.

The Feather and auxiliary main drain.

Besides the Sacramento, the Feather is the only other river channel which acts as a main drain, and is in that capacity auxiliary to the Sacramento throughout the middle portion of its valley course, receiving and leading down the valley the waters of the Yuba and Bear Rivers, as well as those of other smaller streams, to the Sacramento, of which it is the largest affluent.

THE CAUSES FOR RECENT CHANGES IN THE VALLEY RIVERS.

Mining debris in the rivers.

These streams, the Feather, and the Sacramento below the junction of the two, have been greatly reduced in flood-carrying capacity by the lodgment of sand in their channels which has come down the rivers from the mining regions during the past 25 years or more. The presence of this sand in the waters and in the beds of the upper rivers, constitutes the present cause of the changes in the channels of the lower streams spoken of; but its precipitation and retention in the last mentioned channels have been greatly increased by other causes, which are now to be mentioned.

A defective levee system.

The attempts which have been made to keep the flood-waters off the swamp and basin lands by the construction of levees, have not been conducted according to any uniform plan, or upon any system which could be generally successful. The result has been in a measure satisfactory to the projectors of these works at some points, or in some localities, at the expense, however, of others, and even a larger territory, where failure, partial or complete, is apparent. By this unequal treatment the natural order of things, with respect to the regimen of the stream, has been interfered with in a measure to still further impair the even capacity of the channel in the several succeeding divisions of its course, to pass the waters which are brought to it.

The Sacramento—Its natural condition.

In the natural state of the stream the waters of the Sacramento River, at times of ordinary flood, just overtopped the banks—thus spreading in small quantities in innumerable places along its course—and found vent into the basins (without that material sudden checking of the current which must happen when a large quantity of water is diverted at one place), and the banks were gradually and uniformly built up by the annual deposit of sediment thereon.

Effect of crevasses.

The construction of levees stopped the general escape of waters in the manner described, and they are now confined, for comparatively long distances, and then escape in large volume through crevasses or breaks which occur annually, or are left open from year to year. New divisions of the stream into two streams, as it were, are thus formed at many points, and, as a result of such division of waters, the regimen of the main channel is disturbed, and its flood-carrying capacity diminished by the shoaling which takes place below each point of division, while the increased scouring power which should be acquired by concentration of the water is nullified in effect by the

irregularity of the flow caused by the considerable local losses o water through the crevasses.

Effect of faulty leveeing.

The faulty location of levees, with respect to the proper trainin of the current and to the shape or trend of the channel, as well a with regard to the width or space between those on the opposite bank of the river, has restricted the effectual water space unequally in succeeding reaches of the river, and, producing inequalities in the movement of the flood-waters, by causing eddies, whirls, and bars, ha resulted in an elevation in the flood line, while the increased scouring capacity which should be acquired by the concentration of flood between banks has been locally nullified by this increased irregularity of flow.

Cut-offs in an upper division of the river.

Certain cut-offs which have occurred during late years in the uppe portion of the middle division of the river, between Colusa and Chic Creek, while they have hastened the drainage of the river abov them, have had a bad effect upon the general regimen of the river by hurrying the waves of flood down upon the division below which was already of comparatively small capacity.

No treatment of the river as a drain.

Thus, in reviewing the situation, we find that, while the work undertaken by individuals or combinations of individuals into districts—each striving for his or their own local interest—have tended to diminish the efficiency of the stream, nothing whatever has been done toward the general treatment of the river as a flood-carryin channel, a drain in the preservation and improvement of which all have a common interest.

MINING DETRITUS AND THE VALLEY RIVERS.

Intimate connection of the subjects.

The connection between these drainage questions and the "debri problem" is so intimate, and the satisfactory settlement of the forme depends so much upon an engineering solution of the latter, that i may seem proper here to discuss this last mentioned subject, and elucidate whatever conclusions may be arrived at concerning it. Bu this would necessitate a long and not altogether relevant digressio from the main object of this particular portion of my report. Moreover, it is a subject worthy of special consideration, and will be treate in a separate paper under the title of "The Debris Problem." Meantime, so far as this question affects the river problems, I now announc certain primary conclusions respecting it, and ask attention to Par III of this report, for a more detailed consideration, based upon suc data as I have thus far been able to secure.

Improvement of the natural drainage lines.

Taking the streams through the valley in the condition in whic their channels now are, it is within the scope of engineering wor not only to restore them to their former comparatively good conditio but to make them capable of carrying away a very much greate momentary volume of water than they have ever been able to provid

for; and this end can be attained, and the improved channel maintained, it is believed, at an expenditure of money by no means out of proportion to the benefits which will result from it, and the dangers to be warded off.

The sand-flow from the mountains.

But this cannot be accomplished at reasonable cost on the lower rivers if the supply of sand, annually brought down from the cañons above by the eastern tributaries, and liable to be brought down upon the occurrence of one of the periodical extraordinary large floods, remains undiminished.

Reservoirs of sands.

The Feather River (below the mountains) and its main tributaries, as well as the American River, in their several courses through the valley itself, the main cañons of these larger streams (except the Feather) for considerable distances within the foothills and at points well up in the mountains, and many of the side ravines tributary to all these main cañons, are now vast reservoirs of detritus, whence will come for years in the future, with each wave of flood-water, a volume of sand calculated not only to maintain the lower Sacramento River in its present condition of deficient carrying capacity, but to further impair its efficiency in that respect.

Arrest the sand-flow where now reservoired.

It is within the range of engineering work to check the flow of sand from the upper rivers to a great extent, and to ward off the danger which exists from the presence of this material where it is in position to be brought down in large quantities from the mountains and foothill cañons, by the construction of dams and the placing of other obstructions in its way, and thus causing its lodgment and retention in the cañons; and this can be done in a rude, but effectual manner, gradually, as circumstances require, and, it is believed, at a cost not inconsistent with the dangers warded off and the measure of damages averted.

Prevent the sands from entering the cañons.

The more material that is put into the cañons, however, the more expensive will be the work of restraining the flow of sands into the valley rivers; and hence, it is most important that washings from the mines should be reservoired otherwise than in the main cañons, if possible. It is believed that this can be done with respect to the most injurious materials, the sands and a portion of the finer sediment, in a number of cases at least, by dumping only the gravel and stones into the cañons, and conveying the mud-laden waters, with the sands, to settling reservoirs. The possibility and cost of doing this can only be determined, in each case, by a special engineering examination of the property and the surrounding country. These examinations it has been beyond my power yet to make.

Divert low water-flow of streams at foothills.

More than this, further to do away with the evils which may arise from the continued running of mud-charged waters into the rivers, it is possible to divert the low water flow of the streams which come from the mining regions (except the Feather River) at or near the

points where they emerge from the foothills, and to conduct their waters to settling reservoirs upon the rolling lands which border the foothills, whence they could be used for irrigation or returned to the natural channel after clearing; and this, it is believed, can be done at an expense not inconsistent with the direct benefits derived and the dangers averted.

Divert sands into the basins.

And still again, it is possible to divert a large portion of the water and sediment of several of the more heavily charged rivers, notably the American and the Bear, not only at low but at comparatively high stages also, into the low sinks or basins of swamp lands, and there cause the deposit of the material which injures the river channels. Without doubt this can be done very much to the benefit of the lower streams, and certainly to the advantage of the low lands covered in the future.

THE POSSIBILITIES IN THE DRAINAGE OF THE VALLEY.

Rapid drainage in the valleys, and the debris problem.

The success of these works assured, it becomes possible, as heretofore asserted, permanently to greatly improve the lower rivers; but this can only be accomplished, with any considerable degree of satisfaction, by an uniformly thorough treatment of them as water-carrying channels throughout their several courses, according to one broad design, executed in all and each of its parts when and in what manner the phenomena in nature developed make its prosecution necessary.

What may be expected from a successful system of works.

By a proper system of works and a wise government of them we may expect to reclaim the swamp and basin lands of the valley from overflow by the waters of ordinary floods, and to raise the lowest swamp depressions so as to render them susceptible of cultivation in the future, by the deposit thereon of a portion of the sediment which the rivers each year must bring down. We may expect, also, permanently to shelter the cities of the valley from inundation, and to render the main streams navigable in a greater degree than they ever have been.

Great inundations.

But let it also be remembered that these remarks apply, as heretofore described, to the case where we deal with the ordinary floods of the valley, for no limit can be assigned to the amount of water which may at some time in the future come down this valley; and, as in the past there have been phenomenal inundations, now spoken of as "the flood of '62," "the flood of '52," etc., so may there yet be others as great or greater than they, against the general spread of which no human foresight can provide, nor secure protection for the great body of the lands in the valley. Of course, limited tracts, such as the sites of cities and towns, can be raised to elevations or protected by embankments over which, in all probability, no flood-water will ever reach. Yet even these are safe only in comparison with other lands less elevated or less securely protected.

Great floods must spread.

Dupuit, a writer of repute on river phenomena and the science of hydraulics, has quaintly remarked that levees may be divided into two classes, to wit.: submersible and insubmersible levees. The first are those which have been overtopped by former floods; the latter differ from the former only in being less frequently submerged in the past, or are awaiting submergence by a larger flood yet to come in the future. And so it should be fully understood that floods will occasionally come which must be allowed to spread. But we may guard greatly against their ravages by a proper system of works; and, with prosperity and plenty for nineteen years, a rich and populous section should be able to afford to be submerged on the twentieth; and, moreover, should be prepared for it, so that the protective works would not be injured, and the lands overflowed would be benefited rather than otherwise.

THE PRESENT CONDITION OF THE SACRAMENTO RIVER.

The divisions of the river.

For the purpose of a preliminary consideration of the regimen of the Sacramento River, it may be set out in nine divisions, each of which embraces a portion of the channel commencing and ending at points where, when in flood, it naturally receives an important tributary, parts with a material portion of its waters through an outlet channel, divides distinctly into two streams, or again unites into one.

Relative capacity of the divisions.

Thus each represents a portion of the great drain subjected to a task somewhat uniform throughout its length, in carrying away the waves of flood-water; and each succeeding division in the series down the valley should be of capacity sufficient promptly to pass onward, or hold in reserve within itself, the waters brought to it.

A cursory review of the field.

I commence at once a cursory consideration of the field from the point of view of individual and relative capacity of the several and succeeding divisions of the river's channel.

FIRST DIVISION.

From the Iron Cañon to Stony Creek, a distance of 58 miles, the Sacramento receives many small tributaries. It is for the greater portion of the distance bordered by a narrow strip of bottom land, which at times of ordinary high flood flow, is covered with water.

Floods in the First Division.

The escape of water from the main channel in this division (until within five or six miles of its lower end) does not contribute to any wide spread inundations of lands below; for throughout the course (with the exception just mentioned) the bottom lands are bordered by plains or rolling lands lying above the elevation of flood-waters in the main stream.

Character of flood-waters in First Division.

Thus until below the mouth of Chico Creek on the east bank, where we have the exception mentioned above, all the waters escaping from the main channel within the first division return to that channel almost immediately, or are led along parallel with and near to it, through subsidiary channels and bottom land depressions, for short distances, without effecting great damage, or long depriving the proprietors of the use of their lands; for the duration of floods seldom exceeds two days in the upper part, and four days in the lower part of the region considered.

SECOND DIVISION.

From Stony Creek to Butte Slough—a distance of 53 miles—the Sacramento does not receive a single tributary, but is flanked on each side by lands depressed one to ten feet below the immediate banks; the line of lowest depression being from two to seven miles away from the river channel.

Floods in the Second Division.

The disastrous and wide-spreading overflow of the valley commences near the head of this division—just below Chico Creek on the east and Stony Creek on the west side of the river—so that the great work of handling the waters that come down must begin here for the protection of lands situated many miles below, as will be more fully explained hereafter.

Character of channel and banks.

The waters which enter the head of this division of the river, including those of Stony Creek, constitute all that are presented for passage onward to the head of the next division, there not being any tributaries below Stony Creek. The channel has not thus far shown itself of capacity sufficient to accommodate the ordinary high floods' waves, the waters of which were wont, in part, to leave the river and its fringes of bottom lands and escape into the basins heretofore referred to. The channel itself is exceedingly irregular in width and depth throughout this division—more so than in any other portion of its course. The banks generally are inclined to cave down, but on each side of the strip of bottom land, which is a mile or two in width and through which the main channel meanders, there is a line of hard bank land.

Alignment of channel cut-offs.

The alignment of the channel is exceedingly irregular, and at many places constantly changing; cut-offs occur sometimes naturally, and can be readily caused artificially. The channel, however, is already on much greater grade and of larger dimensions than that of the division below; the natural grade of the country is greater, and the soil, for the most part, admits of active scouring effect and the rapid formation of a larger cross section than already exists.

Leveeing in the Second Division.

The construction of levees, which are generally set back on the hard rim lands in this division, has for the most part prevented the overflow of waters into Colusa basin on the west, but the great line of

escape into the head of the Butte basin on the east, near its upper end, and into the lower portion of the same basin from near the lower end of the division, is still open to the waters of ordinary high floods, although for many miles the direct overflow eastward is also prevented by levees throughout the middle portion of the division.

Butte Slough.

Butte Slough, at the lower end of this division, is a large escape channel for flood-waters into the lower end of the Butte basin above it, and the upper end of the Sutter basin below it, on the east side. Attempts have been made to close this slough and keep it closed by means of earthwork embankments and timber structures; but either from the flood force alone, or the action of persons opposed to the closure, who have on occasions destroyed the works, these efforts so far have failed.

Drainage from the east.

The waters from Butte and Table Mountain Creeks, streams from the mountains on the east, flow into the Butte basin, and are led through that and the Sutter basin to the river far below. These waters come so near entering the river in the lower portion of this division, that they may be regarded as of a right tributary thereto.

Drainage from the west.

The drainage from the Coast Range, brought down by numerous small creeks opposite this division of the river, spread into the Colusa basin, generally from 5 to 15 miles away, and gravitate towards the lower end of the next division below.

THIRD DIVISION.

From Butte Slough to Sycamore Slough, at Knight's Landing, a distance of 49.8 miles, as in the second division. There are not in this any tributaries, and low land basins flank the river on each side, generally three to seven miles away, and five to fifteen feet below the elevation of the banks.

Character of the channel.

Here we have a contracted, but deep channel, and for the most part an exceedingly crooked one, with banks generally very firm and not inclined to cave. The irregular and oftentimes grotesque alignment of the banks results in bad eddies, whirls, and water dams at time of flood, and thus seriously impedes the flow of the waters, so that what is termed "bend resistance" is in this division at a maximum.

Fall and shape of channels.

The longitudinal fall of the river and of the country is less throughout this division than in the one above; the channel is materially smaller in dimension, but more even in cross sectional form than in the preceding division, there being no shoalwater bars, except in one limited locality, between Grand Island Mills and Wilkins' Slough, where some comparatively wide and shallow places exist.

Slope back into basins.

Along this portion of the river the surface of the ground generally falls rapidly away from the banks back toward the low basins, the fall frequently being as much as 12 feet in 1,000 feet. This is particularly the case on the east bank, and at places opposite to the points or bends which extend toward the east.

Prospect of cut-offs.

Although the very crooked channel presents many points where cut-offs might be looked for from natural action, yet the firmness of the soil, consolidated and protected by plant growth along the banks, seems to have prevented any occurrence of the sort for a long time in the past, and there are no indications of material natural changes of this kind for the near future.

Deficient capacity.

Throughout this portion of its course the channel, as compared to that in the division above, is very deficient in capacity. It does not carry on the average more than half the water brought to it in time of ordinary high flood, the remainder escaping through Butte Slough and certain crevasses into the Sutter basin on the east, and occasionally rupturing the levee on the west, in its endeavor to flow into the Colusa basin.

Leveeing in the Third Division.

Levees have been pretty generally built throughout this division, and owing to the considerable fall in the ground's surface back from the river, they are located close to the banks, sometimes as close as they can be built, to save the elevation in construction. The levee on the west bank is generally a very good structure, and located with more judgment—further from the bank—than that on the east, which latter, with the exception of the upper four and five-tenths miles protecting Swamp Land District Number Seventy, is an irregular and weak embankment, often not over two to three feet high, and indeed near the lower end of the division it can be hardly said that there are any levees at all on the east side. It is understood, however, that these levees have been raised generally a foot since examination of them was made by this department. Two large outlet channels—Upper Sycamore and Wilkins' Sloughs—have been closed by the works connected with the system of levees on the west side.

Drainage from the east.

There are not any tributary streams which approach the Sacramento from the east in this division, all the mountain drainage from that direction being intercepted by the Feather River, and carried on down the valley to a lower point of joining. The Sutter basin lies between the two streams; each thus act for this portion of the valley as a main drain.

Sycamore Slough.

As in the next upper division, all drainage from the west is intercepted by the Colusa basin. The outfall of this basin is naturally Lower Sycamore Slough, into the river just above Knight's Landing. When the river is in ordinary flood there is no drainage way for this basin, for the flood elevation at the lower end of the drain is 13 feet

above the general elevation of the bottom of the basin, nine miles up the valley. The levee and works connected therewith now prevent this back flow of water, so that the creek waters from the Coast Range rest in the basin until the subsidence of the river flood, when they are drained away.

Drainage from the west.

But if the Colusa basin is to be kept entirely free from water, it will be necessary, in addition to keeping the waters out of it from the river, to intercept the flood flow of the Coast Range streams which now drain into it, and carry their waters to the river at some point at a sufficient elevation to give them free outfall into the river at all stages of the waters thereof. The Knight's Landing ridge is the natural site for the entrance of such a tributary; hence the commencement of a new division at this point.

FOURTH DIVISION.

From the mouth of Sycamore Slough, at Knight's Landing, to the mouth of Feather River, 14.8 miles in distance by the river, but only 5.5 miles in a straight line, there are no tributaries, and low land basins flank the river on either side—the lower end of Sutter basin being on the left and north, and the upper end of the Yolo basin on the right and south.

Character of the channel.

The channel here presents an aggravated case of the disease with which it is afflicted in the preceding division—an extreme contraction and contortion of its waterway. The cross sectional form is good and nearly uniform, there being but one shoal, which is at Knight's Landing, immediately at the head of the division. The banks are firm, and generally densely overgrown with trees and shrubbery, which prevents erosion and the formation of cut-offs, for the opportunities are so favorable for these that doubtless they would occur but for this protection to the narrow isthmuses which separate succeeding reaches of the channel. The slope in this division is reduced considerably by the filling that has taken place at the mouth of the Feather.

Leveeing in the Fourth Division.

The levees in this division are generally very poor, although some lands on the south side at the head of the Yolo basin are protected from immediate flooding by fairly good embankments. On this side, however, a large crevasse exists, through which the water pours each year, and other breaks occur almost annually; while on the opposite side the floods move at will over the bank, back and forth, out and into the Sutter basin.

FIFTH DIVISION.

From the mouth of the Feather River to the mouth of the American River, a distance of 19.7 miles, there are no tributaries, and the river is flanked by the Yolo basin on the west and the American on the east. In addition to the waters of the Sacramento proper, those of the Feather and its tributaries are presented at the head of this division.

Character of the channel.

The channel has a good width, an average of nearly three times that through the two preceding divisions, and previous to the general silting up which has occurred below the mouth of Feather River during recent years, it maintained a good depth and cross sectional form, except at one or two places, notably at the "Six Mile" Shoals, above Sacramento, where there has always existed, so far as is known, a wide and shallow reach. Now, notwithstanding the changes alluded to, the river is a better one to deal with in this division than in the two preceding, for with its considerable width it still maintains a fair depth, though its general capacity is, under present circumstances, greatly decreased from what it formerly must have been.

Alignment of the channel.

Through this division the river is not a crooked one, though two sudden changes of direction exist, to the detriment of its maintenance free from eddies and bars. The banks do not cave down, and are generally protected by a fringe of willows. There are no places where cut-offs are in the least likely to occur, for the channel does not double around upon itself, as it does above the mouth of Feather River; moreover, the slope in this division is already considerably greater than in the one preceding.

Leveeing in the Fifth Division.

The surface of the ground falls rapidly back toward the low land basins, from the river, hence we find levees, as in the third division, placed near the banks. With the exception of the division from Knight's Landing to the mouth of the Feather, the leveeing in the division now being considered is the most uneven in construction and effect of any along the river. For 6.5 miles from the upper end on the east bank the continuation of the Feather River levee is fairly good, and under present circumstances protects a strip of land behind it from overflow by the waters of any ordinary high flood. Thence on down there is no levee worthy of mention on the east bank, and flood-waters flow through deep cuts into the American basin. On the west bank the levee is very good at places for several miles; generally it is sufficient for three-fourths of the distance, under present circumstances; but a number of large crevasses exist, through which the flood-waters pour in large volume into the Yolo basin.

SIXTH DIVISION.

From the mouth of American River to the head of Grand Island, a distance of 27.7 miles, there are no tributaries, and the river is still flanked by two basins, the Yolo on the west, and the Sacramento and Mokelumne basins on the east. The waters of the American River are presented to this division at its head, in addition to those brought to the foot of the division above through the river channel itself, and through the American basin, which here empties into the river, the waters which escape from it on the east above, together with water drained from the mountains between the American and Bear Rivers, brought down by Auburn Ravine and other similar streams. These are the last waters tributary to the river on the east bank.

Character of the channel.

This division of the river closely resembles the fifth, but the channel for the upper portion of its course is somewhat more crooked and less even in width and depth. Local bars exist, as for instance the Haycock Shoal—a serious obstruction to the flood flow. There are no localities where cut-offs might occur, as the channel does not pursue a tortuous course; and the banks, as a general thing, resist the undermining action of the current, so that considerable changes of alignment are not to be expected.

Flood capacity of the channel.

As in the preceding division, the general flood capacity of this portion of the river has been much diminished of late years by the deposit of sand therein, which has filled the deeper reaches in an astonishing degree, and raised the shoal places or bars, so that now there is not any more, if as much water, as there used to be on them, though the general plane of the water surface has been raised several feet.

Leveeing in the Sixth Division.

The surface of the ground generally falls away from the river, so that levees have been located near to the banks. Here are to be found some of the best levees along the river. That on the east bank is rarely breached, and is more nearly uniform in disposition and construction than any similar piece of levee of the same length in the valley, excepting, perhaps, that on the west side of the river above Knight's Landing to Colusa, and that around Grand Island. On the west bank, though fairly good levees exist at notable places, sometimes for several miles in length, the structure as a whole through this division is very defective, for there are long distances where it is slight and of uneven disposition and construction.

Flood slope.

At the upper end the flood slope in this division is somewhat greater than in that above next preceding, owing to the receipt of the tributary waters of the American River and basin, but towards the lower end this slope is materially decreased in approaching the point of bifurcation, in the next division at the head of Grand Island.

SEVENTH DIVISION.

From the head to the foot of Grand Island, a distance of 18.28 miles by one route, and 11.9 miles by the other, the river runs through two channels, called Steamboat Slough and Old River, respectively. A few years ago Steamboat Slough was the deepest and probably the most capacious of the two, seeing that it is 6.38 miles shorter than the other, and consequently has the greater grade, and its cross sectional dimensions were probably as considerable and more regular. Now, however, it is found much filled with sand, and its flood-carrying capacity in a great measure destroyed, for during the past season, at time of flood, it carried only half as much water as did Old River, which is not in much better condition than it was years ago.

Steamboat Slough.

Steamboat Slough is somewhat crooked for 4.5 miles of its course, at

the upper end, but it is a well aligned channel thence on down. The entrance to it is very badly disposed, being narrow and sharply defined at right angles to the general course of the main stream. It gradually increases in width after the first 4.5 miles of its course, so that for the lower seven miles it is more than twice as wide as it is above. And so we find it shallow, and becoming more so, for the sands drawn in at the head are deposited, when the current slacks, in the wider reaches below, and a dam is thus formed against all material and water entering above. Other possible causes for this rapid shoaling will be adverted to elsewhere. The Hogs-back Shoal—a very shallow place—has always interfered with navigation and been an obstruction to flood flow in this channel, and it is now as bad or worse than ever. The south bank of Steamboat Slough is generally very good and firm, but that on the north is for the most part low and swampy. No caving, however, has ever occurred worthy of mention.

Old River.

The Old River channel has improved somewhat since the rapid silting up of Steamboat Slough commenced. Near its head is a channel of good form, but for the lower 6.5 miles of its course it is wide and shallow. Generally it is well aligned, though one or two bends exist, which are doubtless material obstructions to the flood flow; but these could not be cut off, even if it were desirable to do so. Georgiana Slough is an outlet from this channel into the Mokelumne and San Joaquin Rivers, and at time of flood carries a material portion of the Sacramento waters altogether out of the river. The banks of Old River are generally firm, but towards the lower end the first soft swamp banks are found. There has not been any caving, however, of moment, except at one limited point where protective works have been resorted to with success.

Leveeing in the Seventh Division.

Around Grand Island there is a good levee except on the Steamboat Slough face near the lower end, where it was badly damaged by the flood of 1878. On the north side of Steamboat Slough there is no levee worthy of mention. On the south and east side of Old River a fairly good levee, which has done good service, exists, particularly throughout the upper portion of the division. These levees are all as close to the river bank as they could be built; placed so, probably, because the highest and firmest land was there found, and consequently the cost of construction reduced, and because a saving was thereby effected in tillable land to the owners of the property.

Grade and capacity.

With respect to the river above, the Steamboat Slough has a much greater grade, and the grade of the Old River channel is somewhat greater, also, through the upper portion of its course. Hence we find, at the head of Grand Island, a hump in the flood profile of the river. The two channels, as they exist, are not of sufficient capacity to carry away the floods which could be brought to them from above by the main channel as it exists; but this main channel is shoaling for some distance above the point of division, so that it is being adjusted to the decreased capacity below, and this effect will, of course, gradually work on up the river. There can be no doubt that the levees in this division, particularly at the head of Grand Island, should have been

set further back to make way for ordinary floods, though their present position cannot be made altogether accountable for the shoaling which is going on above the point of bifurcation.

EIGHTH DIVISION.

From Grand Island to the point of junction with the San Joaquin River, opposite Collinsville, a distance of 15.8 miles, the river flows in one channel, except in the short distance opposite Rio Vista, where Wood Island makes a division of somewhat more than a mile. The waters brought down by the Old River and Steamboat Slough channels unite at this division, as also those brought down the Yolo basin, west of the river, from the overflow of the Sacramento on that side below Knight's Landing, and from the floods of Cache, Putah, and other creeks, which drain the Coast Range on the west. Thus, should the Cache Slough, which drains the Yolo basin, deliver as much water at its mouth as escapes from the Sacramento above at the time of maximum flood, the channel through this eighth division would be doing full duty, under present circumstances, in carrying it. These are the last waters tributary to the Sacramento.

Character of the channel.

The channel in this division is generally of good alignment; but it is very uneven in width and depth, with one notably narrow point, and another wide and shallow reach, both of which changes are material obstructions to the flood flow. The banks are for the most part low, and, comparatively speaking, swampy, with the exception of where the river sweeps close to the high and firm upland, which it does at several points on the northern side.

Leveeing in the Eighth Division.

On the south side of the river there is a levee throughout this division, which has been found generally efficient, where constructed high enough. It is still, comparatively speaking, a low levee, and has been overtopped on several occasions, to be referred to hereafter. On the north side there is no levee of importance, and the marsh land is quite low.

Capacity of the Eighth Division.

Generally, the river in this division is a very large one. Compared to the channel at any point above, it is more nearly proportioned to the duty it would have to perform were all the waters confined to one channel, and more easily improved in flood carrying capacity than any other division, for the obstructions here are purely local, and of a character easily removed.

NINTH DIVISION.

From Collinsville to Suisun Bay the Sacramento is in one channel with the San Joaquin River. This is a wide, open estuary, and it is difficult to say where the river ends and the bay begins. The shores are salt marsh; tidal action is here at its full, both at low and high water stages of the river. Shoals exist, one notably opposite Collinsville, just at the point of junction of the two streams; and this shoal is an obstruction to the escape of flood-waters from the Sacramento

River. Further than this the ninth division of the river has not been examined by this Department. It was in part re-sounded by the Coast Survey in 1879, but the results of this work have not been secured for study in time to be considered in this part of my report, and will be considered hereafter.

LEADING DEFECTS OF THE SACRAMENTO RIVER.

The river deficient in capacity.

After this examination of the river throughout its valley course, if we glance over the field we find a channel which, in its present condition, is not, in any one single division of its course, capable of affording passage to the maximum volume of the ordinary high floods of the valley as they would be presented to it if confined between banks with levees all brought to a height uniform with the average of those which now exist in the several divisions, and in most divisions, even if the levees were brought to a height uniform with the highest that exist.

Defective divisions.

We find, moreover, several divisions of small capacity, generally, throughout their length; as for instance the third and fourth, from Butte Slough to the mouth of Feather River, deficient in grade and width, and suffering from excessive bend resistance, thus diminishing the flood flow by reason of its tortuous course. And again, the upper end of the seventh and the lower end of the eighth division, where the river is restricted in capacity by the effect of the division of its waters at Grand Island, and the construction of levees close up to the banks of streams already too narrow. It should be understood that these remarks, although true to a certain extent as applicable to the past and present, are especially meant to apply should the attempt be made to run the channels up to their maximum capacity by an uniform system of leveeing.

Local obstructions.

And still again, we find serious local obstructions of long standing in certain divisions, as, for instance, the Six-mile Shoal in the fifth division; the Haycock Shoal in the sixth; the Hogs-back in the seventh; the Newport Shoal in the eighth; and the Collinsville Shoal in the ninth division.

The question of capacity.

Hence we are to conclude that before providing for that portion of the waters of ordinary floods which the river is not generally now in a condition to carry there are certain special defects of its channel to be rectified, in order that it may work as a drain up to an uniform standard of efficiency throughout its course, and then the question of disposal of surplus waters will come up on its merits. Shall this channel be made large enough to carry these waters, or shall it be supplemented by other lines of escape?

THE FLOODS OF THE VALLEY.

Designation of the flood region.

As there are in the Sacramento Valley two great sources of flood

waters, as heretofore explained, so are there two great seats of overflow, one above the mouth of Feather River, in which the Colusa, Butte, and Sutter basins are specially involved, and one below Feather River, in which the Yolo and American basins, and all lands bordering the river from Sacramento to the foot of Grand Island, are threatened. The first may be called the upper valley flood, and the second the lower valley flood.

The upper valley flood region.

The upper valley flood may be occasioned under existing circumstances altogether by waters from northern streams. It is due directly to an insufficient capacity of the river in the second and third divisions of its course, from Stony Creek to Knight's Landing, and, indirectly, of course, to insufficient capacity in the divisions below. Or a partial flood may be occasioned in this upper valley by high water in the Feather River alone, when the greater part of the Sutter basin would be submerged by back water, principally entering near the lower end. Such a flood would be due directly to an insufficient capacity in the Feather River, below the mouth of the Yuba, and in the Sacramento fifth division, from the mouth of Feather River to the mouth of the American, and indirectly to deficient capacity in the Sacramento division below.

The lower valley flood region.

The lower valley flood may be occasioned alone by the waters of Sierra streams—the Feather and its tributaries and the American River; that is to say, there may be more water presented to the Sacramento River by these streams when the upper Sacramento is only at its ordinary winter stages than it is now capable of carrying through its fifth, sixth, and seventh divisions, without submerging the American and Yolo basins, even if existing deep gaps in the levees and banks were closed and no water escape until it overtopped existing levees at some points; though, of course, the American basin would be partly submerged by backwater from its lower end, where there is no levee at all.

Interdependence of floods.

A lower valley flood may, then, be almost entirely independent of one in the upper valley, though, of course, this is not generally the case; and furthermore, an upper valley flood might occur if the general overflow was produced by the waters of the Sacramento, while the Feather remained low, without occasioning a flood in the lower valley, if existing gaps were closed, though, of course, as in the previous case, the American basin would be partly filled by backwater; for the channel below the mouth of Feather River is of sufficient capacity to carry the maximum quantity of water which would reach it, under these circumstances, from an ordinary upper river flood-wave.

The highest flood source.

Though, as things now are, the American and Yolo basins ordinarily receive large volumes of water through existing crevasses, before the greater volumes come from the upper valley, the ordinary high flood-waters, so called, in the river below the Feather, as well as above

it, generally come from the northern streams—the Upper Sacramento and its tributaries—the most distant source of supply, whose maximum flow arrives at the head of the lower valley flood region from 30 to 40 hours later than those from the eastern streams.

The delta islands.

In addition to these two primary seats of inundation and threatened flooding, there are the low islands below the seventh division of the river, which might not be endangered, if evenly leveed throughout, though there were overflow in the flood regions up the valley. Particularly, under existing circumstances, in the seventh division of the river, might there be inundation of considerable magnitude in the upper flood region, involving also the American basin, and threatening all lands east and west of the river below the American, without precipitating a volume into the river below Grand Island, which it could not carry if the overflow into the Yolo basin was prevented. This will be more fully explained hereafter.

EFFECT OF LOW LAND BASINS.

Deceptive appearances of floods.

In the present condition of the river and adjacent country, the ordinary floods seem much more formidable than they really are. They spread over a wide area, and make a great appearance of water, but were it all confined to a channel, and made to pass off as rapidly as it came down—not allowed to accumulate in the low basins from one freshet to another—the aspect would be quite different.

Escape of waters from the channel.

These basins become partly filled by the first freshets of the season, whose waters escape through deep crevasses and sloughs into them.

Effect of the early freshets.

The early freshets bring down a vast amount of sediment—light sand and earth and clay—from the eastern rivers. Instead of carrying this material on through to the outfall of the river, a portion of their waters escape into the basins described, and the sands are deposited in the main river channel. Thus the first and moderate freshets, which could easily be carried away between the banks of the river as they exist (provided that the crevasses and sloughs were closed), and which might carry away not only their own sediment, but clear out the channel also, if they were confined to a channel of good regimen, serve to deposit more material in the main channel, and to fill with water the basins of relief.

The basins not the relief they appear to be.

When the later and higher freshets of the season come, their first waters also find vent in the basins, and spreading over those already there, raise still higher the wide expanse that looks so formidable. Thus when the highest flood wave comes—the only one, generally, which is in great excess over the general capacity of the river to transmit—the basins of relief are already filled to near the flood mark, and the waters running in every direction—into the river at some points and out of it at others—and driven about by the winds, make a great

appearance of a big flood, which is not due to the real volume of water which should be passing down the valley at that time.

Deposit of the early freshets.

And furthermore, this highest flood wave of the season finds the channel bed in the lower rivers raised by the deposits of the earlier freshets, as before described, and is forced to cut up and take away material which should not be in its way. Thus in the higher freshets, generally the last of the season, the bottom of the lower rivers is swept out, but not in time to prevent this extra material which has been deposited by the earlier waters from causing the higher floods to rise still higher than they would have done if they had none but their own sediments to push along with them.

Condition of the drainage system.

Here, then, we have the picture of the abnormal condition of things which exist in the Sacramento Valley; a condition which is annually growing worse, instead of better. The deep cuts or crevasses out from the river are becoming more decided, thereby diverting more water, causing more uneven flow in the main channel, and a corresponding shoaling thereof at points which would not take place if the channel were forced to carry all that it could carry, and none were diverted at any one point, except in small quantity, where the channel was full and unable to carry all the water brought down.

FEATHER RIVER BEFORE THE ERA OF MINING.

The channel in 1848.

The channel of Feather River has been subjected to such considerable changes during the last 10 or 15 years, that a description of its present condition would not convey a just idea of the real character of the river. It was, in 1848, a clear-water river, with a well defined high bank channel. It left the mountains in a rocky bed, and ran alternately over short cobble-bottom rapids, where, at low water, but one (1) or two (2) feet of depth was found, and through pools of several miles in length, sometimes with water 10 to 25 feet in depth at the lowest stages. This character continued to near the point of entrance of the Yuba, from whence, on down, fine gravel and sandbars appeared in place of those coarser materials, with long reaches intervening where the water was from 8 to 15 feet deep, on the average, at its lowest stages, but becoming less deep, and sand only appearing on the bars, as it approached the Sacramento.

Bottom lands above the Yuba.

A bottom land of sandy alluvial soil, varied, particularly on the east bank, by a rich, light brown surface wash from the hills, brought down by the Honcut and other smaller streams, extends from a point about five miles below the foothills to within about the same distance of the mouth of the Yuba, and was generally, in the early years of settlement, above the reach of all ordinary flood waters.

High land plains above the Yuba—east side.

The plains from the foothills, on the east, slope rapidly toward the river, and there is not any outlying depression, except the Wyandotte Valley, tributary to the Honcut, which still has quite sufficient slope to the river for purposes of good drainage.

West side.

On the west a high, plain ridge extends parallel to the river's general course, and about one or two miles away from it, for about ten miles below the foothills. Thence on down the plain lands slope from the edge of the river bottom land away to the west and toward the basins which border the Sacramento River, for the most part 15 to 20 miles away.

Mouth of the Yuba—site of Yuba City.

The Yuba formerly entered the Feather River about at right angles to its course, a comparatively narrow clear water stream well down between banks, running over a gravelly bottom, and crowded the main stream over against the high plain land formation on the west, thus cutting off the bottom lands on that side. The bank was high above all floods, fifteen (15) feet above low water, and firm ; and here the town known as Yuba City was built.

Sutter County Slough.

From the end of the bottom land above Yuba City a depression in the plain lands, away from the river, and extending close behind the town, takes the form of a shallow slough, 400 to 500 feet in width, pursues a course south and west across the plain, diagonally away from the river, to the low lands heretofore designated as Sutter basin. This slough was naturally an overflow channel to the river, and its presence now marks the appearance of direct connection between the hard plains on the west and the bank upon which Yuba City stands.

Site of Marysville.

On the east bank of the Feather River, just above the Yuba, a strip of bottom land, not over 200 or 300 yards in width, extended, and on the somewhat high plain which came down to the Yuba River just behind, the town of Marysville was built.

West bank, south of Yuba City.

The waters of the Feather, at times of flood, before the contraction of levees, always found passage through the slough behind Yuba City, and sometimes topped the banks and rim of plain land at low points above within the first ten miles, and coursed across the plains to the basin beyond. The higher banks were seldom, however, overflowed below the mouth of the Yuba on the west side; but the bottom lands on the east side have always been subject to flooding almost annually.

Mouth of Bear River.

The Bear River formerly entered the Feather in a contracted but well defined channel from the northeast, through a low bottom land several miles in width which here skirts the larger streams on the east. In the acute angle between the two streams, above the mouth

of Bear River, a depression in the bottom land, several miles in length, and lower than the bank of either stream, constitutes the first basin-like formation east of the Feather. It is referred to hereafter as the *Bear River Basin*.

East bank, from Yuba to Bear River.

Down to within several miles of the mouth of Bear River the line of demarkation between the higher plains and the bottom lands can be readily traced on each side of the Feather. Here the task becomes more difficult; and within a few miles below, as in a similar case on the Sacramento about Colusa, the bottoms are at points higher than the former plains behind.

Site of Nicolaus.

Just below the mouth of Bear River, the high land, without intervening depressions, extends from the plains to the river bank, and hereon the town of Nicolaus is situated. Except in seasons of most extraordinary floods, this point was formerly above highwater mark.

East bank, below Nicolaus—American Basin.

Immediately below here the river's banks, built up above the lands to the east, continue to become relatively higher; and thus is commenced that basin which extends almost uninterruptedly east of the Feather and Sacramento Rivers to the mouth of the American, and which has been called the *American River Basin.*

West bank, near the mouth of Feather.

Five or six miles from its mouth, it may be said that the last vestige of the high plain lands west of the Feather merge into the basin which skirts the Sacramento River on the east, from the Buttes southward; and thence to the junction of the rivers the banks of the Feather form but the rim to this, the *Sutter Basin.*

THE CHANGE IN CHARACTER OF FEATHER RIVER.

Near Oroville.

Of late years the channel of Feather River has been filled greatly, and the general character of its profile much changed. Where it comes out from the mountains, at the town of Oroville, there formerly existed an ordinary high-water channel but 400 feet in width, with pools 30 to 40 feet in depth at low water, alternated by rapids where, at this low stage, the stream poured only a foot or two deep over cobbles and boulders. These deep holes are now filled with cobblestones, sand, and gravel; the plane of low water has been raised about six feet, and the general slope of its surface, which was formerly very riregular, as heretofore described, has been rendered more even and steeper for the first five miles of its course below, where the greater irregularities formerly existed.

Mouth of the Yuba, and above.

Below the mouth of the Yuba the whole river bed has been raised, until now there are no more long reaches of deep water and the alternate shoal bars, but a wide, uncertain channel in a sandy bed, of almost even rate of inclination down to the Sacramento, with a gen-

eral slope much increased over what it formerly was, and other changes, as hereafter more fully described.

Effect on the adjacent lands.

The bottom lands all along the Feather River are now naturally more subject to overflow than they were, and, of course, the river is more than ever inclined to flow over its western banks into the Sutter and American basins.

PRESENT CONDITION OF FEATHER RIVER.

As we now find it, the Feather River may be described as follows:

First division.

From Oroville to Burt's Ferry: A moderately well aligned stream, with good banks, underlaid by gravel, and not inclined to cave. This distance is 12.8 miles.

Second division.

From Burt's Ferry to the Yuba: A crooked stream; numerous small, round bends; banks less stable than above, but still good; coarse sand bottom; the channel flanked by bottom land, subject to overflow, particularly on the east side. This distance is 24.2 miles.

Third division.

From the mouth of Yuba to Nicolaus, near the old mouth of Bear River: A very well aligned stream, but with two remarkable exceptions, where the channel makes a right angle set-off for half a mile or more each time, and then as suddenly resumes its former course. The length of this part of the channel is 19.6 miles.

Through this portion of its course, the Feather River has comparatively low banks; indeed, these are at points almost indeterminate; its width is quite irregular, and its channel through a shifting sand bed. The adjacent bottom lands, though raised by sand and sediment deposits, are subject to overflow by each ordinary high water. The banks are inclined to cave, and generally covered by willows and other bottom land growth. Just above Nicolaus, a considerable portion of the flood-waters of the river annually flows over its western bank into the Sutter basin.

Fourth division.

From Nicolaus to the Sacramento: A remarkably well aligned channel, with but one exception—a sudden turn to the right, and back again. The length of this division is 10.4 miles.

Through this portion of its course, the banks of the river are lower, and the waters frequently break over them into the Sutter basin on the west. The channel is even more irregular in width and shifting in its sandy bed than in the division above.

The grades and dimensions of the Feather River channel will be found in tabular form in a subsequent portion of this report.

Raising of the river beds.

It is quite certain that the bed of Feather River, and that of the Sacramento below the point of junction with the Feather River, has been greatly raised during the past 30 years, and that since 1862,

when sands were brought from the upper cañons in great volume, the rate of filling has been more rapid than prior to that time. The raising of a bed of a river is first made apparent by the increase in elevation by its lower water plane or level, the movement of which is a fair indication of the average filling on the shoals of the channel. Thus the Sacramento may have reaches of 5 to 10 miles in length, of water 15 to 40 feet in depth at its low stage, alternating with short shoals where the water will only average 5 to 10 feet in depth; and the low water plane will be held in position by the shoals, which act as partial dams. There is abundant evidence to show that this was the character of the channel below the mouth of Feather River in the early days of its navigation. Now we find these deep reaches in great measure filled up and the shoals raised, as evidenced by the increased elevation of the low water plane. Feather River, though less decided in its character formerly as a deep channel, has nevertheless been greatly filled, particularly at and below the mouth of the Yuba.

The low water plane of these rivers has been raised about as follows: Sacramento River—Head of Grand Island, 1½ to 2½ feet; Sacramento, 5 to 5½ feet; mouth of Feather, 3 to 4 feet; Knight's Landing, 1 to 1½ feet. Feather River—Nicolaus, 3 to 4 feet; mouth of Yuba, 13 to 15 feet; Oroville, 5 to 6 feet.

From what has been said it will be understood that these figures do not represent the full depth of filling in the beds of the rivers. It is difficult to determine just what this has been, for there were so few surveys made in early years with the results of which the present channel may be compared. It is known, however, that in front of the City of Sacramento, and for near two miles of the length of the channel, the average filling has been to a depth of 15.2 feet, and the maximum about 25 feet since 1854, when a survey was made under the direction of the Town Council by the City Surveyor. A copy of a map showing soundings made at that time has been secured. The condition of the river is found noted thereon, and the reading of the guage for that low water stage is known; so that the data are good, and the results of comparison the most reliable at my command. This subject will be more fully discussed in Part III of this report.

TABLES OF CHANNEL DIMENSIONS AND GRADES.

The following tables show the relative dimensions, grades, etc., of the several divisions of the Sacramento and Feather Rivers:

SACRAMENTO RIVER.

Divisions of the Channel.

Number of the Divisions	Location of the Divisions.	General Direction of the Divisions	Distance in an air line, Miles	Length of channel, Miles
I	Iron Cañon to Stony Creek	S. 18° 00′ E.	40	58
II	Stony Creek to Butte Slough	South	33	53
III	Butte Slough to Knight's Landing	S. 24° 30′ E.	29	49.8
IV	Knight's Landing to Feather River	S. 78° 00′ E.	5.5	14.8
V	Feather River to American River	S. 24° 45′ E.	14.3	19.74
VI	American River to Grand Island	S. 9° 30′ W.	20.3	27.7
VII	Old River Channel Steamboat Slough	S. 30° 00′ W.	10.0	18.28 11.9
VIII	Grand Island to Collinsville	S. 55° 00′ W.	12.3	15.8
IX	Collinsville to Initial Point	S. 52° 00′ W.	2.75	2.87

Total length of the river through the valley:
By way of Old River channel .... 249.2 miles.
By way of Steamboat Slough channel .... 255.6 miles.

FEATHER RIVER.

Divisions of the Channel.

Number of the Divisions	Location of the Divisions.	General direction	Distance	Length of the channel
I	Oroville to Burt's Ferry	S. 21° 00′ W.	9.4	12.8
II	Burt's Ferry to Yuba River	S. 4° 00′ E.	18.0	24.2
III	Yuba River to Nicolaus	S. 5° 00′ E.	15.9	19.6
IV	Nicolaus to Sacramento River	S. 16° 00′ W.	8.4	10.4

Total length of the river channel through the valley .... 67.0 miles.

SACRAMENTO RIVER.

Channel dimensions and grades in the several divisions.

Designation.	First Division—Iron Cañon to Chico Creek.		Second Division—Chico Creek to Butte Slough.		Third Division—Butte Slough to Knight's Landing.		Fourth Division—Knight's Landing to Feather River.		Fifth Division—Feather River to American River.	
	Low Water	High Water	Low Water	High Water	Low Water	High Water	Low Water	High Water	Low Water	High Water
Elevation of water at upper station, in feet	258.5	284.3	110.4	130.5	40.95	62.96	19.97	36.12	16.03	33.81
Elevation of water at lower station, in feet	110.4	130.5	40.9	62.9	19.97	36.12	16.03	33.81	9.83	28.00
Difference of elevation between stations, in feet	148.1	153.8	69.4	67.5	20.98	26.84	3.94	2.31	6.20	5.81
Average grade per mile, in feet	2.55	2.65	1.31	1.27	0.42	0.50	0.27	0.16	0.31	0.29
Maximum grade of any five miles, in feet	4.4	4.6	1.7	1.7	0.54	0.66	0.36	0.19	0.40	0.47
Minimum grade of any five miles, in feet	1.4	1.6	0.4	0.6	0.29	0.42	0.22	0.05	0.19	0.17
Maximum grade of any one mile, in feet	5.5	4.7	1.7	1.7	0.55	0.80	0.45	0.30	0.70	0.55
Minimum grade of any one mile, in feet	1.1	1.5	0.3	0.5	0.27	0.25	0.10	0.00	0.13	0.06
Average width of channel, in feet	500.	580.	450.	500.	249.4	281.2	286.	320.0	517.	683.
Widest average for any one mile, in feet	700.	800.	620.	650.	343.4	383.4	300.6	332.8	709.	770.
Narrowest average for any one mile, in feet	300.	375.	300.	320.	192.5	216.0	245.6	286.2	427.	502.

SACRAMENTO RIVER—Continued.

Designation.	Sixth Division—American River to Grand Island.		Seventh Division—Old River.		Seventh Division—Steamboat Slough.		Eighth Division—Grand Island to Collinsville.		Ninth Division—Collinsville to Initial Point.	
	Low Water	High Water	Low Water	High Water	Low Water	High Water	Low Water	High Water	Low Water	High Water
Elevation of water at upper station, in feet	9.83	28.00	4.66	16.15	4.66	16.15	1.13	9.42		
Elevation of water at lower station, in feet	4.66	16.15	1.13	9.42	1.13	9.42	0.15	2.58		
Difference of elevation between stations, in feet	5.17	11.85	3.53	6.73	3.53	6.73	0.98	6.84		
Average grade per mile, in feet	0.19	0.43	0.19	0.37	0.30	0.57	0.06	0.43		
Maximum grade of any five miles, in feet	0.30	0.58	0.30	0.43	0.39	0.75	0.07	0.54		
Minimum grade of any five miles, in feet	0.06	0.28	0.17	0.27	0.21	0.33	0.06	0.32		
Maximum grade of any one mile, in feet	0.43	0.60	0.40	0.45	0.45	0.85	0.07	0.60		
Minimum grade of any one mile, in feet	0.05	0.20	0.17	0.20	0.20	0.08	0.05	0.30		
Average width of channel, in feet	531.	627.	381.	417.	407.	468.	1,163.	1,297.		
Widest average for any one mile, in feet	740.	850.	610.	626,	580.	597.	2,084.	2,100.		
Narrowest average for any one mile, in feet	442.	480.	274.	282.	215.	259.	687.	704.		

FEATHER RIVER.

Channel dimensions and grades in the several divisions.

Designation.	First Division—Oroville to Burt's Ferry.		Second Division—Burt's Ferry to Yuba River.		Third Division—Yuba River to Nicolaus.		Fourth Division—Nicolaus to Sacramento River.	
	Low Water	High Water	Low Water	High Water	Low Water	High Water	Low Water	High Water
Elevation of water at upper station (above low tide on the Bay)		160.5	84.8	106.0	49.4	65.7	25.6	41.7
Elevation of water at lower station (above low tide on the Bay)		106.0	49.4	65.7	25.6	41.7	16.0	33.7
Difference of elevation at lower and upper station		54.5	35.4	40.3	23.8	24.0	9.6	8.0
Average grade per mile		4.26	1.46	1.67	1.21	1.22	0.92	0.76
Maximum grade of any five miles		4.58	2.06	2.64	1.80	1.82	1.36	1.07
Minimum grade of any five miles		3.80	0.06	1.18	0.74	0.68	0.49	0.50
Maximum grade of any one mile		5.20	2.50	2.80	1.83	2.15	1.80	1.10
Minimum grade of any one mile		3.20	0.05	1.00	0.60	0.80	0.35	0.50
Average width of channel	200.	260.	280.	340.	330.	620.	340.	510.
Widest average of any one mile	470.	520.	320.	400.	410.	820.	370.	580.
Narrowest average of any one mile	150.	180.	200.	300.	240.	510.	280.	460.

REMARKS ON THE TABLES OF CHANNEL DIMENSIONS AND GRADES.

SACRAMENTO RIVER.

The data available.

The data from which this table is prepared is complete and reliable for the third, fourth, fifth, sixth, seventh, and eighth divisions, and about two-thirds of the second. For the remainder of the second (above Butte City), and for the first division, the data are good, but not being so much in detail, small errors in the averages may exist.

The water line given.

A part of the sixth and all of the seventh, eighth, and ninth divisions are within the range of tidal influence; and the water elevations given within these divisions are those for the low tide planes during both the low water and flood stages of the river.

Effect of defect at Grand Island.

It should be remarked here that what is said elsewhere in this report concerning the break in the flood line at the head of Grand Island may not be so apparent from this table, for the reason that the grade above, as here represented, is the average throughout the sixth division, while that taken in the discussion referred to only extends to Freeport from the head of the island. Haycock shoal and the action of the American River make the grade in the flood plane steeper above Freeport; hence the effect of the Grand Island defect in regimen is taken as extending only to Freeport in the extreme flood stages. Furthermore, the half tide slopes are considered in the discussion, whereas the slopes here given are for extreme low tides only, which at times of high water are felt a small part of the way up Steamboat Slough and Old River Channel.

To obtain a fair idea of the break in the profile at the head of Grand Island, look at the minimum grade for five miles of channel in the Sixth Division, which occurs first above Grand Island, and the maximum grade of five miles in the Seventh Division, which occurs just below the head of Grand Island. Thus, at flood stage, for five miles above the head of Grand Island, the grade of the water line is 0.28 feet per mile, while below the same point at the same stage, in Steamboat Slough, the grade is 0.75 feet per mile, and in Old River 0.43 feet per mile, showing the effect of the defective capacity past Grand Island in holding the water back above.

THE INITIAL POINT.

The initial point of the surveys of this Department, from which all distances on the rivers are reckoned, is situated in mid-channel, in the main stream—the San Joaquin and Sacramento combined—on range between the lower points of New York Slough and Spoonbill Creek, which join the main channel opposite to each other. This point is opposite New York Landing, where tidal observations were made for determining a low water plane of reference. Above this plane elevations are given in feet.

The Ninth Division of the channel is made to end at the initial point, because there are no observations and data to give dimensions and slopes below it.

EFFECT OF THE SUTTER BASIN WATERS.

The effect of the Sutter Basin waters and channel defects of the Sacramento is seen in the flood grade line of the Fourth Division, where at the very highest water there was no perceptible fall in the river just above the mouth of Feather. The floods from Feather River sometimes produce the same effect.

FEATHER RIVER.

Effect of the Yuba.

The grade line of Feather River is exceedingly irregular. The filling at the mouth of the Yuba makes almost a still-water pond of the Feather above for 6 to 8 miles during low water stage, and produces a rapid descent for a corresponding or greater distance below. This effect is apparent, though in a less marked degree, during the flood stage also.

Effect of the Sutter basin waters.

The Sutter basin supply of water seriously disturbs the Feather River flood slope at times, by affording a greater quantity of water than the Sacramento can carry below the mouth of Feather; the Feather itself is backed up and forced to run over into the basin at a point above, and where it has yet the elevation to do so.

THE THREE DRAINAGE PROBLEMS OF THE VALLEY.

From what has been said, it will be seen that there are three main problems in the drainage of this valley:

First—To insure a sufficient outfall from the foot of the lower valley flood region, that it may be drained without flooding the delta islands.

Second—To insure a sufficient water-carrying capacity from the foot of the upper valley through the lower valley flood region, in order that the former may be promptly drained without causing damage below. And,

Third—To provide drainage way sufficient to bring the waters of ordinary flood volume, from the upper Sacramento, near Stony Creek, through to the head of the lower region, without overflowing the upper region of freshet floods.

Certain circumstances complicate the first two problems, and make it necessary to consider them for a moment as one. For instance, if by diverting water from the river near the head of or at points in the lower flood region, that is, at or below Knight's Landing—we might conduct it by a separate channel to the Bay, and in such volume as to effectually relieve the river below the point of diversion and Feather River mouth without causing inundation of the low lands, then the first and second problems would apparently be solved at once. I consider this mode of possible relief first.

The Yolo basin.

The Yolo basin lies west of the Sacramento, and extends, parallel to the general course of the river, from near the mouth of Feather to the eastern foot-slope of that high land known as the Montezuma Hills, against and near to whose southern base the main river channel is situated for nearly the entire division of its course from Grand Island to Collinsville. The line of lowest depression in this Yolo basin, near its upper end, is about one mile from the river; thirty-two miles below, opposite Courtland, it is about two miles from the river; while opposite Sacramento, nearly midway between the extreme points, it is five miles away. In the middle 20 miles of this distance the bottom of the depression falls 15 feet, giving an average grade of nine inches per mile. Hence the surface of the ground, in the bottom of the basin, is about level to near its lower end, ten miles further, where it raises to the hills on the west and south, and to the bank of the Steamboat Slough channel of the river on the east and south.

Comparison of river and basin grades—Cache Slough.

The average grade of the bed of the river opposite the portion of this basin, whose bottom line has a fall of nine inches per mile, is about three inches per mile. At its extreme southern end the basin is drained by Cache Slough, which joins the Steamboat Slough channel of the river about half a mile above the lower end of Grand Island. This drainage slough extends across the low level portion of the basin, and comes to the river at right angles to its general direction. From the fact that there is no sand brought into it, Cache Slough is a deep and commodious channel—more so than the river immediately above it; and it is kept open by the swell and ebb of the tides, which have free action in it, especially at times of low water.

The waters of the basin.

This basin receives the drainage from the Coast Range on the west, brought down by Cache and Putah Creeks principally, and also the overflow waters from the Sacramento, which escape over its west bank and through the crevasses below Knight's Landing. These waters, for the most part, enter the basin near its head. When not in very large volume, they are held back by the growth of tules, and do not find their way rapidly down the steep grade of the basin; but, after filling the deeper depressions thereof, they are delivered gradually through Cache Slough, to be drained away by the river below Grand Island.

The floods of the Yolo basin.

When, on the contrary, after the basin has been partially filled, there is a large accession of water from the creeks or the river suddenly precipitated therein, it delivers at its lower end through Cache Slough, and over its rim into Steamboat Slough, a large flood volume in advance of the rise which comes regularly down the river, and thus temporarily gorging the river below Grand Island, creates a perfect water-dam in the Steamboat Slough channel, and causes an elevation of the flood up-stream as far as Sacramento. If this occurs

when the river above is already at flood level, it is likely to produce disastrous results.

The flood of 1878.

This state of affairs occurred on the 20th and 21st days of February, 1878, and resulted in the overflow of the Grand Island levee on the Steamboat Slough face, at several points near the lower end, where the waters came across the river, struck the levee at right angles, and ran up stream as well as down in this channel for a short time. The same flood-wave made several breaches in the levee south of the main river, below Grand Island.

Proposed relief through Montezuma Hills.

To guard against such inundations, and to relieve the river from its surplus waters below the mouth of Feather River—through the lower flood region and the delta islands—it has been proposed to construct a canal which shall carry a portion of the waters of the river, and the waters from the creeks of the Coast Range, into Suisun Bay by wayof a new outfall, to be made opposite the lower end of the Yolo basin, through the Montezuma Hills.

A relief canal.

This project takes two forms:

First—To tap the river, and draw from it into a canal, to be carried on grade around the west side of the basin, such waters as may be surplus in the main channel, and intercepting the flood waters of the creeks from the west, conduct all, by a comparatively shallow cut, through the hills to the new outfall.

A drainage canal.

Second—To tap the river at one or more points, permit its surplus waters, with those of the creek, to enter a drainage canal constructed along the bottom of the basin to near its lower end, and thence pass, by a comparatively deep cut, through the Montezuma Hills to the new outfall.

The first arrangement would properly be called a *canal of relief* to the river, and an *intercepting canal* to the creek. The second arrangement might claim, in addition to the performance of the duties above named, to effect the complete drainage of the low basin.

Diversion of creek waters.

Aside from these phases of this proposition—because not so intimately connected with the river problem—is the proposition to conduct the waters of Cache and Putah Creeks alone to a new point of outfall, over the Montezuma Hills, without tapping the river at all. The work would be simply *an intercepting canal,* or an extension of these creeks to a new mouth. It is the simplest proposition connected with this entire problem, and therefore will be spoken of first.

THE INTERCEPTING CANAL.

A high grade canal.

The summit of the lowest depression in the crest of the Montezuma Hills is 37 feet above low tide in the bay. Putah Creek, on an approximate grade contour, with a rise of one and a half feet per

mile, is 25 miles distant from this point, and the line continued, on a grade of two feet to the mile, would reach Cache Creek in 18 miles of distance, additional. A cut of 13 feet deep through the Montezuma Hills would afford a grade of two feet per mile also in the first division—to Putah Creek. By this disposition the initial grade elevation at the summit of the hills would be 24 feet; at Junction with Putah Creek, 74 feet; at Cache Creek, 110 feet above low tide in the bay.

Depth of cutting, and grades.

Lowering the whole line ten feet would bring the grade elevation to 14 feet at the summit of the hills. The distance thence to Montezuma Slough is about six miles, and thence out into the bay by the shortest route, six miles further. For this distance of 12 miles, the 14 feet yet to spare of grade would afford a fall of three inches for each of the six miles through the slough, and nearly two feet, respectively, for the first and each succeeding mile thence to grade in the summit of the hills. To pass the waters of Cache Creek (supposing 34,000 cubic feet per second represents the maximum) on to Putah, the canal, on a grade of two feet per mile, would have to be 240 feet wide on an average depth of flow of 20 feet.

Required dimensions.

To pass the flood-waters of Putah Creek (supposing 76,000 cubic feet per second to represent the maximum) on through the hills, the canal, on a grade of two feet per mile, would have to be 535 feet wide, on an average depth of flow of 20 feet. To pass the combined waters of the two streams (taken at a maximum of 100,000 cubic feet per second) the width would have to be 704 feet. It is, however, not at all probable that the flow from both streams would ever be in the same part of the canal at the same time, even to an aggregate quantity represented by the figure adopted; for they are both highly intermittent in character, and their floods are of very short duration each.

Importance of diverting the creeks.

The importance of diverting these streams is not to be measured alone by the increased value of property in the Yolo basin, which might thus be relieved from annual overflow, for circumstances may readily occur when the whole river and island property below Sacramento would be at the mercy of their uncontrolled floods.

Effect of creek flood.

As in 1878, so may these waters at any time contribute largely to the inundation of Grand Island and other island property below, beyond the immediate basin into which they pour, and otherwise comparatively safe from overflow.

A deep channel required for diversion.

If these streams can be turned permanently, it can only be accomplished by creating a *deep* channel for the purpose—one resembling the form and approximating the slope of those in which they run above where they commence to deposit their sediment. Any other disposition would only result in the destruction of the new waterway and damage to property now safe from flooding.

Manner of construction.

To estimate upon the cost of such a canal, at any fixed price per cubic yard of all the material to be moved, would not be doing the subject justice, for the waters themselves should be made to perform by far the greater portion of the labor. Thus a canal at first constructed 10 feet deep, 10 feet wide at the bottom, and 30 feet wide at top, for the entire distance over the plains above the hills, would necessitate the removal of 1,643,000 cubic yards of material. The cut through the hills at the same width on the bottom and down to the grade with the portion excavated to half depth above, would involve a maximum cut of 13 feet in depth and the removal of 93,000 cubic yards of material.

An estimate of cost.

The earth from the canal on the plains should be put in an embankment on the lower side of the canal, at least 100 feet away; the material from the hill-cut could for the most part be moved out lengthwise of the work by means of cars on a tramway, and used to make embankments for the continuation of the canal across the low plains to the slough below. Then,

1,643,000 cubic yards from canal on plains, @ 10 cents per cubic yard	$164,300
93,000 cubic yards from cut through hills, @ 20 cents per cubic yard	19,600
Total cost of construction	$183,900

Other expenses necessary.

In addition to the above, there must necessarily be a leading channel two or three miles long for Putah Creek; a set of regulating gates in the canal just below where it taps each creek; and also a movable dam in each creek, below where tapped by the canal. The process of enlargement would then be each year to plow and otherwise loosen the material in the bottom and on the upper side of the canal, and each wet season to admit as much water in the new canal as it could be made to carry, and no more, flushing out the excavated soil, and effecting the enlargement without great cost.

Levees should not be necessary.

In the course of a few years, the new channel for the creeks would, under favorable circumstances, be excavated below the surface of the plain; no embankments would be necessary; the movable dams in the old channels of the creeks would be replaced by solid earthen embankments (unless it might be desired still to draw water through for irrigation) and the turning of the stream would be effected.

Right of way, etc.

There would, of course, be other expenses attendant upon this work than those alluded to here, as, for instance, property damages, and cost of right of way, and cost of attendance upon the works during the process of enlargement. It is believed, however, that the whole work could be completed at a cost far within the limits of immediate returns from benefits to lands in the Yolo Basin and immunity from danger of flooding the islands below. More particularly would this be the case if the waters of the Sacramento were also not permitted to enter the Yolo Basin, as they do now, through the crevasses above Sacramento.

Examinations necessary.

Whether or not the material to be removed would admit of the inexpensive manner of construction here spoken of, can only be determined by a careful examination of the route, with borings to test the sub-soils.

Conditions to be looked into.

If the streams are now raising their channels at the points where it is necessary to divert them, we might expect the canal-bed to raise also; and this would be an unfavorable circumstance. If, on the contrary, the water can be taken out on suitable grades, where the natural disposition is now to cut down, and carried in grades approximating thereto, then the outlook would be hopeful. This can only be ascertained by watching the streams through at least two seasons.

RESERVOIRS FOR THE CREEK FLOODS.

To reduce the maximum flow of these creeks, and thereby effect a saving in the size of the canal, it may be thought the plan of holding back a portion of their flood by open dams in the cañons might be adopted to advantage. What is said in an appendix to this report on the general subject of this method of dealing with floods, however, should be remembered in this connection.

Cache Creek now regulated.

Cache Creek would be the tributary to this new channel, most distant from its mouth. This stream is made up by two principal tributaries, one of which drains Clear Lake. This lake is already a regulator upon the flood volume in its stream, the time of delivery is set back, and amount of maximum flow is doubtless decreased. As it is now, the freshets from the other branch of the creek come down rapidly, and are led away before there is any large contribution to the main stream from the Clear Lake branch, which follows afterwards. Suppose, now, a reservoir dam were put in at some suitable point on the northern branch, and its waters held back like those of the Clear Lake branch, we may readily understand how the uniting of the two flood volumes, from the two streams, in that event made to come down at the same time, instead of in succession, would form a freshet of greater momentary magnitude than would otherwise occur if the additional reservoir had not been built, even though each of these waves were reduced in volume itself by the effect of its particular reservoir.

Danger in holding back floods.

This same argument would apply in considering a proposition to hold back the floods in Putah Creek, if the two creeks were to be led away in the same canal; for by preventing the rapid escape of Putah Creek freshets we might hold them so that their maximum volumes would be presented to the main channel at the same time that the greatest flood flow arrived from Cache Creek, which, of course, would not only be bad economy, but might result in disaster.

Diversion of the creek waters recommended.

On the whole, the proposition to lead the waters of Cache and Putah Creeks into Suisun Bay, by means of a high-grade canal over

the Montezuma Hills to Montezuma Slough, may be looked to as the groundwork of a probable solution of one of the most difficult problems on the drainage of the valley, but its efficacy will depend largely upon what course of treatment other features of the case receive, as will hereafter appear more fully, and its possibility and cost can only be determined after a fuller examination than the time thus far elapsed could permit of being made.

Storage of the creek waters not recommended.

But the plan of holding back a portion of the flood-waters of these creeks, or of either of them, by means of dams—either open or closed—constructed in the cañons, is one of very doubtful policy, though further investigation may show it to be, in this particular case, free from the grave objections which there are generally to such works. It is hoped the opportunity may be afforded of reporting definitely on this whole subject, when the lapse of another season has given opportunity to judge of the present action of the streams in question, with respect to the movement of their beds.

THE RELIEF CANAL.

A project to divert a portion of the waters of the river at Gray's Bend or Knight's Landing—the head of the lower region of floods—and conduct them to the bay, on the route heretofore described, has already been reported on by the Engineer to the Sacramento River Drainage Commission, under date of November 28th, 1879.

The conclusions put forth in that report are here summarized and enlarged upon.

Conclusion of the District Drainage Engineer.

First—In the present condition of the drainage lines of the valley, the waters which are regarded as surplus below the proposed point of diversion cannot be put into the projected relief canal, because they enter the main channel below that point. The point of diversion selected is itself the lowest down the valley whence such a canal could be taken out from the stream and maintained, for the reason that thence to tide water the river is flanked by low basins, across which banks of the canal would have to be too high for safety ; and hence, the projected work would not serve to relieve the districts below from danger of flooding.

The effect of the creek sediment.

Second—On the grade upon which it is possible to construct the canal—four inches to the mile—its waters would not carry on to the Bay the materials which would be brought into it by Putah and Cache Creeks, which have grades of four feet and over to the mile; and hence the main canal would be filled up and destroyed. It was also shown in this report that the cost of the proposed work would be excessive; but with that point for the present I have nothing to do.

The second conclusion is reasonable, and, to say the least, calculated to weigh heavily against this particular proposition, under whatever form it may be considered. It should be remarked here, however, that the same argument does not apply against the proposition heretofore considered, to divert the creek waters above through a high grade canal, for the reason that the channel for this latter purpose

could be put on a grade sufficiently great to keep itself clear, while that which has to tap the river cannot.

Creek sediments might be held back.

The materials brought down by these streams possibly could be held back to a great extent, for a considerable time, at least, by dams constructed in the cañons and ravines above. Whether this could be effected in a degree so far to relieve the waters from sediment as to render their introduction into the low grade canal safe, is very doubtful. If this were done we might expect great erosion of material would take place in the beds of the creeks themselves, where their waters would be confined by levees in their courses across the plains (and there must be comparatively very heavy grades), which material would be deposited when the velocity of the waters was checked in the canal of high grade.

A high and low grade canal, too.

Cache and Putah Creek waters might be taken in a high grade channel, as heretofore explained, to the cut through the hills, and there joined with waters brought forward in a low grade canal from the Sacramento River, from which place of joining the combined volumes could be conducted through the hills in the same cut on a sufficient grade to keep the channel clear.

Construction of the cut.

By this arrangement the high grade canal and the cut through the hills could be constructed on the inexpensive plan heretofore spoken of; and it is probable that the cost of the combined works—high grade and low grade canal—would not exceed the cost of the low grade canal alone by the original plan wherein the creeks were to be taken directly into it opposite their points of debouchment from the hills. More particularly would this be the case if it were necessary, as it certainly appears to be under such arrangement, to build dams to hold back the solid materials which would otherwise fill the low grade canal. Thus disposing of the objection to the relief canal, based on the ground that the creek water sediments would destroy it, the proposition comes up on its merits as a relief to the river.

The river in its present condition cannot be relieved.

The first conclusion of the Engineer to the Drainage Commission heretofore cited, is based upon the present condition of affairs in the river system, viz: That sufficient water now enters the river channel below the point of proposed diversion at time of ordinary high floods to cause the flooding of Yolo and American basins, even with the crevasses now existing in the levees closed; and hence, the canal would not so far relieve the river below as to warrant its construction.

The lower valley floods.

It has been hereinbefore asserted that the eastern tributaries, the Feather and the American, might readily present sufficient water to the Sacramento below the proposed point of diversion to overtop much of the existing levees, when the upper Sacramento River was only at ordinary winter stage. This condition of affairs would prob-

ably occur but very seldom; but under present circumstances a large accession to the waters in the Sacramento River below the mouth of Feather, at times of ordinary high flood, is received from the Sutter basin, between the Sacramento and Feather Rivers. This water comes principally from the upper Sacramento River, and enters this basin at its head, as well as at points below, through crevasses in the levees, which heretofore have occurred almost annually.

Why the river cannot be relieved under present circumstances.

Coming down the valley by this short cut, after the basin has been filled by the earlier freshets of the season, the waters of the higher floods are precipitately presented to the channel at the head of its fifth division, the mouth of Feather River, and thence on down there may be a large surplus in the river as it now exists, without its being possible to decrease the amount by diversion where a canal can be constructed, namely: at Knight's Landing, which is above where the great supply of water comes in. For, let it be remembered that this supply is drawn, as it were, from an immense lake with a free outlet, and if all of the water coming down the upper river channel were diverted into a canal at Knight's Landing at such a time, the supply to the river below the mouth of Feather would be just as great, for more would come down out of the lake if not kept back by the river water crowding past, only the supply would probably not last quite so long.

Diversion at Knight's Landing.

Thus, under present circumstances, diversion at Knight's Landing would not be a relief to the river below the mouth of the Feather. Supposing, however, that the waters of the Sacramento were confined to a channel or channels, and that thereby the amount of maximum flow past Knight's Landing were greatly increased, then it would appear that an abstraction of some certain quantity at Knight's Landing would make that much less for the river to carry below. Here, then, are the circumstances under which this project would come up on the merits of the diversion question. Would the diversion of as much water as could be safely taken through an artificial canal from this point be a real and lasting relief to the river below?

Always danger of harm from diversion of waters.

The question, in the abstract, of diverting water from a stream as a means of immunity from floods therein, is discussed in an appendix to this report. All of the objections to this mode of relief would apply in the present instance with full force.

The Sacramento River sediments.

The Sacramento River, below the mouth of the Feather, is at all times heavily charged with sediment. When at times of high water it has a less percentage of solid material in suspension than at other times, its waters are busily engaged in picking up and carrying forward the material deposited at the bottom by former freshets which had more material than they could carry. And, under any circumstances, this will be the case for years to come; for, keep as much material out of the upper rivers as we may, there will still be much come down to the Sacramento, below the mouth of Feather, from the

stream-beds above. And then, too, whatever treatment may be adopted for the drainage of the valley, the scouring out of the present channels, to a considerable extent, must form a leading feature of it, and the waters may have enough to do to accomplish this work and maintain its results. Hence the diversion of the *clear* waters of the upper Sacramento River would have a peculiarly bad effect upon the action in the channel below. Your attention is asked to a portion of this report where this subject of diverting flood-waters is more fully considered. (See Appendix.)

The relief canal project ill-advised.

As the case stands at present, this project is an ill-advised one, for it certainly would not relieve the river below nor the country above. When it is *known* that the lower river cannot be brought to a capacity to pass the waters of ordinary floods, and when a plan is definitely settled upon and in operation for the prevention of overflow in the region above the mouth of Feather, then the question of relief at the point proposed may come up under more favorable conditions, and with necessities made more apparent and definite. Now, that time cannot arrive for some years in the future—pending a treatment of the natural drains—hence the subject does not seem worthy of more extended discussion at this time.

THE DRAINAGE CANAL.

It has been proposed to drain the waters which now collect in the Yolo basin through a deep cut in the Montezuma Hills into Suisun Bay, taking the water direct from the bottom of the basin after it has there collected. This is one feature of the second phase of the general problem of preventing overflow in the lower flood region heretofore explained. But, as reported upon by the engineer to the Drainage Commission, it was not in contemplation to make the work a means of relief to the river above, but only to carry away the waters of Cache, Putah, and other streams which drain into the basin from the Coast Range. As already shown, these creek waters can probably be taken through a high grade canal by tapping the channels where they come out of the mountains. But the very essence of this proposition is to keep on a steep gradient, so that the velocity of the current attained would insure the performance of the work required, namely —the transportation of its material and excavation of its channel.

What waters are surplus.

Such arrangement would keep the waters of the Coast Range streams out of the basin altogether. Then if, as the Engineer of the Drainage Commission assumes must be the case, the waters are kept out of the upper portion of the basin from the river by means of levees, and if the water is kept out of the lower end of the basin by means of levees and embankments across Cache Slough, etc., there would not be any water in the basin to drain out except that which would rain down upon it or percolate through the swamp soil from the river, and consequently the deep cut would not be necessary.

Relief for the Yolo Basin and the river.

Suppose, however, that it were necessary to relieve the river of a

part of its flood waters, either by diverting from some points at or near the mouth of Feather and American Rivers, or permitting the back water to come into the basin at its lower end from the river through Cache Slough, were the high-grade canal constructed for the Coast Range waters, it would not be possible to make use of the same cut in which to conduct the water from the basin through the hills, because, in lowering the cut to an elevation that would accomplish the drainage of waters from the basin, its necessary grade through the hills would be destroyed, and the creek waters coming in on a great slope, as they must at the commencement of the cut, will simply back up the waters in the basin and prevent its drainage, for the lands of the basin proper are four feet below the high tide at the point of outfall. Furthermore, the creek waters would no longer have the grade and velocity upon which to carry their sediments forward to the bay, and would deposit them in the cut.

The bottom of the basin cannot be drained by the cut.

Then, again, supposing for a moment that this difficulty were overcome, and the waters of the creeks were dispersed so that they could not interfere with drainage of the basin through a deep cut if it were made; still, this could not effectually drain the basin, even though the waters of the river were kept out at the mouth of Cache Slough, for the reason that the surface of the ground over a large area of this basin is only four feet above low tide in Montezuma Slough, into which the waters could go, and the tide rises eight feet in that slough, or four feet above the level of the lands of the basin. Or, in other words, the land to be drained is at the height of mean tide at the outfall—seven miles distant.

Comparative efficiency of the river and deep cut.

By keeping the waters of the river out from the lower end of the basin, and by diversion, as heretofore suggested, of the creek waters through a high grade canal, it would seem that the only use of the deep cut would be to afford rapid drainage for flood-waters which might be diverted from or escape from the Sacramento River into the upper portion of the basin. Admitting, for the moment, the necessity for diverting water from the river above, either into this basin or into a canal therein, the efficiency of a cut for this purpose over the possible efficiency of the river channel itself from the mouth of Cache Slough to the bay, may well be questioned; and herein lies the most important fact with respect to the whole matter.

The proposed new outfall not an open one.

It may be supposed that this cut would end at a point of free outfall into the bay. Such is not the case. At best, it would only be carried to Montezuma Slough, at about a middle point on its course. Now, this slough extends from the mouth of the river, at Collinsville, in a great arc, around the north of Suisun Bay, a distance of 15 miles, and joins the open water again near the lower end of the bay. The land thus inclosed is known as Grizzly Island (with some small islets at the southern end. Montezuma Slough is generally a very shallow channel—at points almost dry at low tide—and quite a narrow one, not more than 300 to 500 feet in width for a considerable distance of its length, and with low marshy banks. Grizzly Island is for the most

part surrounded by embankments which are now sufficiently high above high-tide level to effect its reclamation.

The waters of Montezuma Slough would have to be raised.

In order to put any such volume of flood-water through Montezuma Slough as would afford a material relief to the basin above the hills, it would be necessary to raise the water at the junction of the canal-cut to afford a fall through the slough channel sufficient to carry away the waters into the bay. When this is done we, of course, diminish the efficiency of the canal to draw down the waters of the basin. The whole water plane would be held at a higher level throughout the basin, the cut, and the slough than it would be if the lower end of the cut were at a point of free outfall. The result might well be an inundation of Grizzly Island, and other land already embanked and safe from overflow under present circumstances.

The mouths of Montezuma Slough.

Then, too, where would this water go? As before said, the slough has a mouth which joins the river immediately at its mouth or point of juncture with the San Joaquin River. The waters taken through the hills from the basin would then, in part, at least, return to the river by this roundabout channel and check the free outflow past Collinsville into the bay. This might be a more unfavorable condition of affairs for the low island property below the mouth of Cache Slough, than to have the water from the basin come into the river through Cache Slough.

The proposed outlet longer than the present one.

For the same reason the deep cut through the hills would not act as a relief to the river if the communication were left open between it, the river, and the basin at the mouth of Cache Slough; the waters would not find a point of free outflow by going through the cut; on the contrary, the distance to such a point of free outfall would be longer than by way of the main river channel. Montezuma Slough would not carry any such great volume of water as would be put into it from the deep cut, without a considerable elevation of its water-plane at the point of junction of the cut with it; and a portion of these waters would find their way back into the river at Collinsville, to the detriment of the carrying capacity of the main channel for the entire distance below Grand Island. These points are all so simple that it is not deemed necessary to encumber this report with any further elucidation of them.

Conclusion concerning the deep cut.

Hence, it appears that there is much of fallacy in the idea that such a cut would relieve any considerable portion of the lands of the basin from overflow, or lessen the danger of inundation to the islands below Grand Island.

Disastrous consequences might result from the deep cut.

Further than this, the creation of this new mouth, as it were, for the river, is a measure of extremely doubtful policy for the future welfare of the whole delta plain and safety of the commercial interests of the State.

Experience concerning the mouths of rivers.

If we are to have any faith whatever in the result of scientific and practical observation and experience, the fewer mouths there are to a sediment-bearing river the better. *The greater the volume of water, the lower the grade it can be carried on,* is the accepted rule derived from engineering experience in such matters.

Application to the case in hand.

As the practical object to be obtained, with respect to the river, is to lower its elevation at the foot of Grand Island, the working of this rule in the flow of the flood volume would defeat this end, if we divide such flow between two channels, instead of keeping it in one, even if the new channel was to be a shorter one, instead of a longer one, to a point of free outfall, and even if it had an entirely independent outlet, and did not pour a portion of its waters back into the river in the face of its outward flow at Collinsville. Then, too, the diversion of these waters from the river at the foot of Grand Island, as in all cases of diversion where the water is heavily charged with sediment, is a matter of doubtful policy on another score.

Division of the tidal scour.

By this diversion a very strong influence, which now acts in keeping the comparatively fine and commodious channel below Grand Island open, would be lost. Not only would the scouring power of the full winter flow be diminished, but the conservative action of the tides, elsewhere explained, would be divided between two channels, instead of being confined to one, and, as the tidal basin would not be materially increased, the tendency would be to make the two channels, combined, only as commodious as the one had been. There are already two serious obstructions to the flood-flow below Cache Slough—two bars, which should be removed ; and one of them is immediately opposite where the Montezuma Slough would return a portion of the diverted floods and cause a still worse bar. Practical observation and study of these questions by the most distinguished and successful engineers of late years, has led to the conclusion, in somewhat similar cases, that such diversion would result in serious injury to the navigable qualities of the river below the point of diversion.

The Mississippi mouths.

It has been shown that if the Mississippi River did not divide into three arms, or passes, as they are called, leading to as many mouths, but continued on in one channel, its waters would escape on so much less grade in the one channel than in the three; that the flood elevation would be lowered at the head of the passes 1.6 feet, and so on up to New Orleans, and beyond. Now, the advantage which the Mississippi gains in dividing, as it does, is to secure a wider field on which to deposit its sediment, and thus it does not build out any one of its mouths as fast as it would a single one, if all in one; and this is a slight advantage as compared to the disadvantages coupled with it.

The Sacramento mouths.

But the Sacramento would gain even no such advantage as this by a division of its waters in the manner proposed, for it has not a wide sea, like the Gulf of Mexico, to dump into, but, as shown, a portion

of the diverted waters return to the main channel, and the other portion would be led by a circuitous route through a shallow slough, and be dumped out upon a mud flat, already, for the most part, bare at low tide. Under these circumstances, if this line of reasoning is sound, it is questionable whether the low cut through the Montezuma Hills would be permitted by the general government, having the interest of navigation in view. And it is more than questionable whether it would relieve the river in an appreciable degree at times of ordinary floods if it were made.

A cut through Grizzly Island.

There might be an entirely new mouth made to the river by cutting through the hills and through Grizzly Island, out into the bay; this would bring the channel to a great mud flat, four miles in width, necessitating jetties to keep it clear, and the effect would still be, as before explained, to hasten the arrival of the time when jetties will be necessary to keep the main channel free and open for navigation below Collinsville. Aside from this, the first cost of the work would necessarily be greatly in excess of that by the plan of making use of Montezuma Slough as a continuation of the new channel, and the damage to property would be greater also.

The deep cut a flood-gate only.

Now, it may be said that this deep cut would be used only to let the top of a sudden flood-wave out, and that the water would not be permitted to go that way, except in event of the channel below Grand Island being gorged.

A better flood outlet to be had.

If this is the only object in view, then it may be shown that a much better outfall exists, into which relief may be had at far less expense, namely: across Brannan Island, from the foot of Grand Island, into the San Joaquin River. This plan will be spoken of in the next article.

Final conclusions concerning the deep cut.

On the whole, it appears that the project for a deep cut through the Montezuma Hills, to drain the Yolo basin and afford relief to the river, is attended with many questionable points as to expediency and utility, aside from the fact that it must be a very expensive operation, for the cut alone might by no means constitute the greater portion of the cost, if it were undertaken. But of this more at some future time, when different plans of relief are considered on the economic basis.

Effect of leading the creek waters into Montezuma Slough.

In this connection it may be remarked, that the diversion of the waters of the Cache and Putah Creeks into Montezuma Slough would not have anything like the effect in raising the level of the water in that slough, that the admission of floods from the Yolo basin and Sacramento River would have. In the first place, the floods of the creeks mentioned are of very short duration up to their maximum limit; secondly, conducting these floods through the long channel they must run through, would greatly reduce their momentary volume, and increase their duration; thirdly, their volume is not so

great as that of the flood which would have to be poured through the hills in the deep cut, to make it worth while cutting; and, fourthly, the high grade canal would be carried to a point on the slough several miles nearer its lower outlet into the bay, and would enter it in such a manner as to send its waters, for the most part, out that way, and not back to the river at Collinsville.

Effect of diverting the creek waters from Yolo basin.

It should also be remembered that the diversion of these creeks would remove the chief cause of choking the river in Steamboat Slough, such as occurred in 1878, afford a greater capacity to the river above the point of choking, and leave more room for water in the river below; so that the relief sought for the island property by the cut through the hills would be in a great measure secured by removing this one great cause of the *sudden* accession of waters in the channel below the head of Grand Island.

RELIEF OF THE RIVER INTO THE SAN JOAQUIN.

The propositions for relief already discussed, have all related to some work designed to dispose of the waters of the Coast Range creeks, and the overflow or surplus waters from the Sacramento, which find their way into the Yolo basin, by carrying them to a new outfall through the Montezuma Hills.

Alternative plans of relief.

Should it be deemed advisable to attempt to turn the creek waters over the Montezuma Hills, it would then become necessary, in order to reap the full benefit from the work, to keep the Sacramento waters out of the basin, at least at its upper end. If the Sacramento, from the mouth of Feather River to the head of Grand Island, is to be relieved of a portion of its flood waters by means of a supplementary channel, undoubtedly the most favorable location for that channel is to the west, in or alongside of the Yolo basin, because the American river would interfere with the diversion on the east side.

A possible relief into the San Joaquin.

Below the head of Grand Island, however, as a measure probably calculated to afford a better outfall for a portion of the flood-waters which are so suddenly presented through the Yolo basin than the river presents, there is the alternative of opening an escape-way southerly into the San Joaquin river.

Floods of the San Joaquin.

This river is rarely in flood at the same time as the Sacramento. Its periods of full flow occur during the late spring months—May and June—when the snows melt in the high and distant Sierras, while full flow in the Sacramento is not to be looked for after March. It does not bring down anything like the amount of sediment that the Sacramento does, so that its shores are comparatively low and marshy. In its lower portion it has much less grade than the Sacramento, and having a more open mouth, the tidal action is greater. Indeed, it resembles an estuary or arm of the bay more than a river, below a point opposite the foot of Grand Island.

The San Joaquin channel a good point of outfall.

By diverting a portion of the flood waters of the Sacramento River into the San Joaquin, they would there find a much better outfall than in Montezuma Slough.

Past relief into the San Joaquin.

There are strong indications existing on Brannan Island, in the shape of the old channels which are there to be found, that at times in the past this has been the line of escape for the sudden eruption of floods from the Yolo basin into the lower Sacramento. Indeed, there was formerly an open channel, known as Jackson's Slough, which extended from Old River, near the foot of Grand Island, through to the San Joaquin. But this slough has been closed for some years, and other channels leading to the San Joaquin from near the Sacramento are still to be traced. If an outfall is to be made in this direction to take the top off the flood from the Yolo basin, its opening must be below the head of Grand Island; otherwise this property would be flooded.

Proposed point of relief into the San Joaquin.

The distance through from the Sacramento to the San Joaquin, opposite the foot of Grand Island, is five and one-half miles. During the flood of 1878, which has hereinbefore been described, the water stood in the Sacramento, at the point mentioned, thirteen feet above low tide in the bay.

The San Joaquin was in its normal winter condition at that time. There was not any flood there, I am told. If this was the case, and I have every reason to believe it was, then the tide was ebbing and flowing freely in that river, and at the point opposite the foot of Grand Island the low-tide level was two feet, and the high-tide six feet above low tide in the bay; or, in other words, the flood-water in the Sacramento, at the foot of Grand Island, was nine feet above half tide in the San Joaquin at a point only five and one-half miles distant. Suppose there had been a connecting channel through, the grade of the water surface would have been nearly two feet to the mile; or, rather, it would not have risen so high in the Sacramento, for the grade of the river flood-line itself was only 0.29 feet per mile.

A great relief might have been had.

Here, in much less distance than through the Montezuma Hills, might have been a free line of escape for that flood. The route lies through a low, swampy island. The cost of construction, as compared to that of the hill cut, would be insignificant, indeed, and the property damage no greater, if as great.

If, then, we are to anticipate the recurrence of the rush of waters from the lower end of the Yolo basin which occurred in 1878, it seems a wise measure to make a wide over-fall escape through the south bank of the Sacramento into a channel to be cut into the San Joaquin.

Effect of the proposed diversion.

It should be remarked that the objection urged heretofore against diversion of waters, on the ground of its causing deposit in the main channel below, does not apply with force as against the proposition

just considered, because it is thus far alluded to only as a channel of escape for a portion of sudden eruptions or waves of flood-water in the river, and would only act for a short time; and because, in the part of the river now under consideration, as will be hereafter shown, the conservative action of the tides will, under proper management, keep it clear.

Conclusion concerning the relief into the San Joaquin.

As a means of relief to be looked forward to with some degree of confidence, this measure is suggested, but its efficiency would depend greatly upon the line of treatment adopted for the river, thence to the mouth of Feather, as well as upon the treatment of the Coast Range creek drainage.

Such relief might not be necessary.

For instance, if the Coast Range creeks were turned over the hills into Montezuma Slough, and the Sacramento were not allowed to overflow into the Yolo basin, at its upper end, then there would be no sudden eruption of waters from Cache Slough and the Yolo basin to provide for at the lower end of Grand Island; and it would simply become a question of enlarging the capacity of the river. In this event, it would be necessary to afford all the relief possible past Grand Island, and then, as an auxiliary measure, Jackson Slough might be used to relieve the Old River channel. To effect a material benefit it would have to be opened and enlarged, probably. But more will be said of this plan hereafter, in speaking of the general treatment of the river.

In any event, the utility of this latter work would only appear after the flood-carrying capacity of the main river from the mouth of Feather River downwards had so far been increased that the volume of flood-waters brought to the point of diversion was such as to threaten overtaxing of the channel below, or if, by making the diversion, a greater capacity could be induced in the river above by affording a more open outlet than would be had otherwise.

The Old River channel to be attended to.

The Old River channel below this proposed point of diversion from it is already wider than it is above, so much so that the water is quite shallow, while above it is comparatively deep. To keep this channel well open, and at the same time to profit by the new outfall gained by the partial diversion into the San Joaquin, it would be necessary to provide for the passage of more water down the Old River channel to the point of diversion than can now pass, or else narrow it below the point of partial diversion, so that it would maintain a better depth.

Advantages and disadvantages.

There would also possibly be urged against a proposition to turn any considerable portion of the flood-waters of the Sacramento into the San Joaquin, the objection that the floods of the latter river might thereby be made to rise higher than they do now, to the detriment of lands now partially reclaimed but already so low and swampy as to be difficult to levee securely.

At present it cannot be said that the effect would be sufficient to

lay a ground for such complaint. In view of the great size of the San Joaquin River below the point where the accession of waters would be had, and in view of the fact that the rivers are so seldom in flood at the same time (indeed never except at times of general extraordinary floods, when there can be no guarantee against overflow of any of the low lands), the probability is that no material effect of this kind would result; and the decided benefit which would accrue from having the very muddy waters of the Sacramento brought in to consolidate the river banks, and in time afford the material wherewith to build good levees, would be an argument in favor of the work.

Present relief through Three-mile Slough.

A considerable portion of the flood-waters of the Sacramento River now find their way into the San Joaquin River through "Three-mile Slough," which joins the two rivers at a point about six miles below the locality just under consideration. This junction is made at a point where the Sacramento has lost so much of its elevation above the San Joaquin, however, that no great amount of relief is effected, for the river above, during flood periods; though the 1878 flood was drawn down by that outlet, so that the surface slope from the foot of Grand Island to it was much greater thence to the mouth of the river.

INCREASING THE CAPACITY OF THE LOWER RIVER.

I have now indicated and set forth in general terms the merits and demerits, as they appear to me, of such plans of relief for the Sacramento River through the lower flood regions, by diversions of waters from their present channels, as seem at all feasible and worthy of consideration.

It yet remains to discuss the improvements of the channel of the river itself to insure the greatest flood-carrying capacity therein.

The groundwork for present opinions.

Preliminarily, I desire to state that the figures given in this discussion are partial results of laborious and extended computations made in this office. These computations are based upon the results of the surveys, examinations, and observations of this department, made during the past year and a half, and more particularly during the flood season when the cross sectional size and the slope of the river was constantly known throughout its valley course, and its discharge was being measured frequently at points between Colusa and the head of Grand Island (below which the operation of the tides interfered with current observations). And this work was supplemented by surveys or reconnoisances of all tributaries from Stony Creek, around the head of the valley, to the American River, together with observations for discharge during the flood flow in some of the largest of these streams as well as smaller ones of the number.

Deductions concerning the flood volumes.

From the data thus obtained, the rate of discharge for each tributary throughout the flood period has been approximately determined (knowing the character and drainage area of all), and tables of discharge made, from which it can be told, approximately, what amount

of water entered the valley during each hour of freshet. These flood volumes being traced down the stream and combined according to their time and place of presentation to the main channel by the rule that the toe of the flood-wave moves with the maximum velocity of the current, and the crest somewhat behind the mean velocity (varying according to the amount of reservoir space outside the channel itself to be filled, and assuming the channel to be of good regimen and sufficient in capacity throughout), it has been determined what would have been the maximum discharge at the head of each division had all the waters been confined within banks.

The results of this work will be submitted more in detail in a separate paper; meanwhile, for brevity's sake, certain extracts only will be herein used.

The ordinary and extraordinary floods.

The difference between the ordinary and the extraordinary floods of the valley have been heretofore explained in this report, and it has been intimated that the immediate object should be to plan for the rapid transmittal of the waters of ordinary floods, and only for the mitigation of the evils from extraordinary floods—such as that of 1862, for instance, which probably must be allowed to spread.

Types of the ordinary floods.

Now, the floods of February, 1878, and of March, 1879, may be taken as types of the ordinary floods of the valley, and as more is known of them than of others, they only are discussed herein.

CHANNEL IMPROVEMENT—GRAND ISLAND TO THE SAN JOAQUIN.

Actual discharge during flood of 1879.

During the highest water of March, 1879, the largest freshet of the season, and observed by this Department throughout its course down the valley, the channel below Grand Island passed about 87,000 cubic feet of water per second, as the largest average for 24 hours of flow.

Discharge really due to the lower river in 1879.

Supposing the channel of the river to have been of good regimen, and of sufficient capacity throughout—had the freshets last mentioned been confined between banks and carried forward to the portion of this river below Grand Island—the greatest volume here presented (leaving Putah and Cache Creeks out, as being diverted over the Montezuma Hills) would have been about 100,000 cubic feet per second.

Actual discharge in 1878.

By a comparison of elevations, slopes, and cross sectional dimensions, I am enabled to estimate that during the high water of 1878, when the large flood-volume came from the Yolo basin, the river channel below Grand Island afforded passage to about 135,000 cubic feet of water per second on an average through the tidal day. True, the levees on the south side were overtopped, for there was more water presented than was transmitted; but then the channel would carry the same volume at a lower level if its defects were removed, as elsewhere spoken of.

Discharge really due to the lower river in 1878.

Not having the data, it is difficult to say what would have been the greatest amount brought to the same part of the river had this freshet been confined. But, from some knowledge of the facts, and comparison of elevations at points where the discharging capacity of the river is known, I am led to believe that, had the creek waters been diverted, it would have been less than actually presented and transmitted under the circumstances of the rush of waters from the Yolo basin, as heretofore described.

The river below Grand Island.

In short, the Sacramento River below Grand Island can be rendered amply capable of carrying the maximum volume of ordinary floods, if that flow is presented to it in due order—as it would be if the whole river above were brought to a proper condition. And the islands south of the Sacramento, below Grand Island, can be protected from inundation during such ordinary flood-flow in the river, by levees but little higher than they now have, if the river is put in good condition past them, and at its mouth; *provided*, the waters are brought regularly down the river, and not through the Yolo basin.

The channel corrections necessary below Grand Island are three in number, as follows:

Proposed channel corrections.

First—Removal of the bar at the point of junction with the San Joaquin, opposite Collinsville; to be effected through the medium of the scouring action of the waters confined to a channel of proper width by jetties.

Second—Removal of the bar just above Rio Vista, opposite Newport, and the enlargement of the Rio Vista channel past Wood Island; to be effected in the same manner—by the construction of jetties from the mouth of Old River channel to the head of Wood Island.

Third—Widening of the channel and protection of Sherman Island shore in the Horseshoe Bend, just above Emmaton: to be effected by placing a series of spur-dikes in the concave side of the bend, to throw the current off and cause cuttings in the other shore, which is a low marsh island, not reclaimed.

The first two of these corrections are of the class sometimes undertaken by the General Government for the improvement of navigation in similar cases, and probably if any considerable appropriation were made for the Sacramento River, these works would be carried forward in that way, for the necessity for them is now being felt by the shipping interests of the river.

CHANNEL IMPROVEMENT—HEAD TO FOOT OF GRAND ISLAND.

Deficient capacity at Grand Island.

In a description heretofore given of the present condition of the river, it has been stated that the channels on either side of Grand Island are now large enough to pass the waters which could be brought to them by the one main channel above; that is, if its levees were maintained at a height uniform with and otherwise up to the standard of those on Grand Island, and along the east side of the river, generally, below Sacramento. As the effect of this deficient capacity, we

find a banking-up of the stream at the head of Grand Island, and an increased grade in the flood-slope down the channels on each side of it. Steamboat Slough is the shortest of these channels, and hence has the most grade.

The changes in Steamboat Slough.

Owing, however, to its exceedingly uneven cross-sectional form, to the unfavorable disposition of its head to receive the currents, and probably to other causes connected with the flood-flow from the Yolo Basin into and across its channel near the lower end, as well as to diminished tidal action, as hereafter explained, this slough has been shoaling rapidly of late years. It is really a *cut-off* in the channel; but these circumstances will not permit it to be effective.

Effect of cut-offs.

Cut-offs have the effect of lowering the flood-height above them, and unless they lead into a place of free outfall they also raise it below them; that is to say, in shortening the stream between two points—which a cut-off does—a certain amount of fall in its surface is saved; and this is distributed partly above by drawing down the water line, and partly below by raising it. Experience and observation have shown that, owing to bend-resistance being done away with, cut-offs generally draw down the level at their heads about twice as much as they raise it at their lower ends.

The river below Grand Island a free outfall.

The Sacramento River below Grand Island, when rectified as heretofore described, may be regarded as a free outfall of the streams above. First, because it will be of ample capacity to pass ordinary flood-waters; and, second, because its flood elevation heretofore at the foot of Grand Island, has been controlled by the waters which have entered it through Cache Slough and otherwise from the Yolo basin, and not by the waters which have gone down the river. So, as the amount which would reach it at any one time of ordinary flood through the channel, if all were forced to run in it, would not be as much as it was called on to transmit during the rush of waters in 1878, the flood-line would not be raised by sending the flood-waters into it on the route of Steamboat Slough.

To make Steamboat Slough the main channel.

Now, in view of the foregoing, and on the principle elsewhere spoken of, that the greater the volumes concentrated, the less the grades necessary in the streams, it may be readily understood that by making Steamboat Slough the principal flood-carrying channel of the river, we would lower the grade.

If, then, in diminishing the slope, we do not raise the lower end—as already shown would not be the case—the upper end would be lowered. This is the desired result—a relief of the river at the head of Grand Island, to induce a greater slope, scouring power, and capacity above.

Result of the observations of the Department.

For instance, the observations made by this Department during the last flood season have shown that the flood-slope at half-tide

through the lower division of the river proper—from Collinsville to the head of Grand Island (15.78 miles)—was 0.2933 feet per mile, and above the head of the island for 13.83 miles of distance—to Freeport—the flood-slope was 0.3304 feet per mile.

If the river were one of good regimen, the slope of the middle division considered—that past Grand Island—would approximate very closely to a mean between the two adjacent to it—above and below. But we find it to be in Old River channel 0.3447 feet per mile, and in the Steamboat Slough channel 0.5305, in both instances greater than that above and that below; and the reasonable deduction is that something is wrong about the channel.

Without stopping here to consider the theoretical explanation of the phenomena, which will be attempted hereafter, I at once proceed to the practical consideration of the facts as they exist.

The distance from the foot to the head of Grand Island, via Steamboat Slough, is 11.88 miles. For this distance the elevation produced at the head of this division by the grade found to exist, is 6.30 feet above that at the foot, and the elevation which would be produced by applying a grade equivalent to a mean (0.3118) between that point in the division above and below, as just spoken of, would be 3.70 feet, or 2.60 feet lower than the flood-line observed. This would constitute the direct relief referred to.

Conclusions from these observations.

If the results of the one season's observations made by this Department are correct, it appears that here is an opportunity for greatly improving the river, namely, by making Steamboat Slough the principal carrying channel thereof.

The effect of relieving the river at Grand Island.

The beneficial effect of relieving the river through this seventh division would, of course, extend up the channel, and would be felt immediately in lowering the actual elevation as far as Sacramento. The tendency of the stream would then be to lower its bed through this sixth division and re-adjust its parts to the new conditions; and so the fifth division, in turn, would be relieved also.

Result of this relief.

Then, if the waters were relieved from the burden they now have to carry from above, if the sand-waves were arrested, we might treat the channel with the view of generally enlarging its capacity by forcing the scouring action of the currents, and which cannot be done to advantage until the defect in regimen at Grand Island is removed. This correction would necessitate the opening of a new head for the channel several hundred yards higher up stream, into which the current would change properly. And it would also necessitate widening its water-way, and straightening it also at the upper end for about 4.03 miles of its course, below which it is of ample width and only needs scouring out and some dredging, perhaps, at the Hog's-back bar.

Studies of this work.

Studies for this correction of the river are being made in this office on the detailed maps which have just been completed, and it is hoped that opportunity will be had to observe the flood phenomena

still further, in order that the results thus far obtained may be verified. Indeed, it is anticipated that further observations will give this matter even a more favorable aspect.

I now come to a consideration of the means whereby the general condition of the stream may be improved.

CHANNEL IMPROVEMENT—LOWER RIVER—INFLUENCE OF THE TIDES.

Land drainage waters.

The cross-section of the upper river (meaning by this term the portion above the Feather River) has for ages past, perhaps, been determined by the flow of the waters of land drainage only, together with local physical conditions whose mode of action is not so apparent.

The normal section of the river channel.

The character of the soil of the river bed, the quantity and kind of material transported by the waters, the presence or absence of reservoirs, relieving the height or prolonging the duration of high water, are elements helping to determine the normal section of the channel.

Determination of the normal section.

Leaving out what is merely local, and which may change from one part to another, the great general fact which governs the size of the river is the quantity of water it is called upon to carry, not spasmodically in great waves of flood of short duration, but habitually for great portions of the year.

Tidal wave in the lower river.

It will be observed, both in respect to the quantity of water carried and to the sources from which this water is derived, that there is a characteristic difference between the lower and the upper river. The latter derives its waters exclusively from land drainage. The former carries not only the land drainage, but also receives from and returns to the sea daily, two very considerable waves of tidal water. While the land drainage is spasmodic in its features—sending down for a month or two in the winter a great contribution, and then slacking down first to a moderate, and then to a smaller flow—the tidal supply remains sensibly uniform throughout the year.

Tidal action during floods in the river.

During the very high stages of the river, the tidal action upon the waters above the division nearest the bay becomes relatively insignificant, but during the low stages of the river, when the flow of low land drainage is reduced to five or six thousand cubic feet per second, the tidal supply becomes much the more important, and this is the condition of the river for some entire years, and for a great part of every year.

Importance of tidal action.

The proposition is well illustrated in the lower San Joaquin, which is a wide, deep, and imposing stream. That it is so is due almost entirely to the daily ebb and flow of a considerable tide in its lower divisions. If this tide were absent, or even if it were inconsiderable,

rising only a foot, as it does at the mouth of the Mississippi, the section of the lower San Joaquin would be determined mainly by its land drainage above, and it must be plain, that under these circumstances, the river would be entirely different in character, and quite insignificant in dimensions.

Volume of tidal flow.

It is, then, not only the daily regularity of the tide, but its actual volume passing a given point, which goes so far to determine its channel section. Now, the quantity of tidal water which ebbs and flows through any given section during the tidal period of six or seven hours must depend upon the storage volume above; and it must also be said that the volume that can pass up a river is as much dependent on a favorable section and slope of channel as it is upon the rise of the tide itself.

Volume to be increased.

These two elements are in a sense complements of each other. If you can, by straightening a channel, or by guiding the greater velocity of tidal propagation up stream, and pass a greater volume, this same water on its return, being concentrated in its action, will not only conserve but will act to increase the depth of the channel.

Progress of the tidal wave.

The velocity of the transmission of the tidal wave is proportional to the square root of the mean depth. If, therefore, the mean depth is reduced by any cause, the velocity is lessened, the rise above becomes less, the quantity of water passing is reduced, the conservative action is diminished, and the useful qualities of the channel are in every way impaired.

Former tidal action in the Sacramento.

It is understood to be true, that 30 years ago the effect of the tide was noticeable at the mouth of Feather, and was as much as two feet at Sacramento. To-day, owing to the increase of slope, the tidal action is not felt above Haycock Shoal, which is about 31 miles below the mouth of the Feather River.

Increase in slope in the Sacramento River.

The increase of slope during the last 30 years below Sacramento is illustrated by the following facts: The low water of 1849 at Sacramento City was 3.85 feet above low water at New York Landing. The high tide mark at New York was then several feet higher than the low stage of the river at Sacramento. Now the average low water stage of the river at Sacramento is more than nine feet above low water at New York Landing, showing an increase of slope of more than five feet in 50 miles during 30 years.

Change in the mean depth in the water of the channel.

While the minimum depth of the channel below Sacramento has not greatly changed, except through Steamboat Slough, and on the Newtown Shoal, it is known that the mean depth has been much reduced. The deep pools have been greatly filled. In these facts we have the explanation of the reduction of tidal influence within recent years, as we ascend the river.

Conservative action of the tides.

If then, we admit the conservative action of the tide—and of this there can be no doubt—we must next inquire whether it is possible to extend the range of ascent of the tide to points higher on the river, and increase its height all along the range. From what has been said it will be understood that this question is only another form of inquiry whether the mean depth of the lower river can be increased and its slope diminished.

Difficulty of increasing the tidal action of the river.

The first answer to this question must, I think now, under present circumstances, be in the negative, for the reason that the volume of sand coming down the stream is as great as ever. The causes which have produced the increased slope, and have encumbered the channels, are still in existence. Not only are the channels now more or less encumbered with sand, but there remains an unmeasured reserve of great extent in the river beds above and in the cañons of the hills, to add influence to these unfavorable tendencies.

Restrain the sand flow.

If these bad influences cannot be restrained, or substantially modified and mitigated, we must continue to give a negative answer to the question. The opinion has been expressed in this report that such modification is possible. If this hope should, by proper action, become a positive fact, the character of the engineering problem would be entirely changed. The Sacramento would then become what we might term a natural river—subject to such influences only, for good or evil, as natural processes produce.

The tidal action can be increased in the river.

Under such conditions, the problem of extending the influence of the tide could be attempted with every confidence of success. It becomes, then, no longer an untried experiment. It is merely a repetition of operations that have been successful in many European rivers, notably the Clyde and the Thames.

It can hardly be necessary to do more here than sketch a general outline of the means of accomplishing these results. This has been really indicated in what precedes, but it may be well to point out here how it will be possible to detect the places where special constructions will be necessary in order to promote the object in view.

To discover the defects of a tidal channel.

A defective condition of a tidal channel may be recognized in one or both of two ways: Either by the abnormal shape of the diurnal tidal curve, which is recorded by an ordinary clockwork tide-gauge, or it may be shown by a sudden change in the slope of the co-tidal line, as shown on the profile of the water surface in the channel.

The defect being evidenced in this way, the cause is sought for in the local section or local slope; the section may be too wide, or too narrow, or ill shaped, an adjacent bar may exercise an injurious influence, or the slope may be too great, or a secondary channel may interfere. In some such way, the cause being clearly established, and the case diagnosed, the remedy is usually not difficult.

Diagnosis of river phenomena.

In river treatment the diagnosis of the case is really the essence of the matter. The facts are so various, and so obscure, that in ascertaining them and disposing them in their proper relation, lies the main difficulty, and in the inability to ascertain and formulate the facts, is the explanation of the failures that have sometimes occurred.

Scouring power of the waters.

These local defects being cured, the natural forces, which are the land drainage and the tidal currents, will then have a fair opportunity to do their work, and the influence of the tide being favored, it will return the service partially in the flood—by disposing the material which it carries on the borders of the channel—and in the ebb wearing a deeper channel in carrying the sands to lower points.

Observations of the past season.

Now, the observations of the past season, conducted in the manner described through the agency of clock-work gauges and connecting level lines, have shown not only the serious defects in the river above, heretofore spoken of, but that the channel bars at the mouth of the river exercise a most pernicious influence on the tidal wave in its passage up the river—prevents its free propagation, and hence diminishes the conservative action just outlined. A striking illustration of this is found in the fact that the high tide level below the bar is a foot higher at the low stage of the river than it is at Rio Vista, 13.8 miles up stream, along a deep, open channel. Thus the bar prevents the filling of this basin by the tides, and their beneficial action in scouring the channel above is limited; hence, for this reason also, as well as that it is an obstruction to the flood escape, this bar should be removed, as heretofore recommended.

Time required to improve a tidal channel.

This sketch of operations is not for those of a day or a year. The engineering devices will bring about no violent or sudden change in the river. They must first arrest or modify the destructive agencies, and then they must aid the force of nature in restoring the channels and further improve them.

To improve the Sacramento River channel.

It has required the expenditure of vast amounts of time, ingenuity, money, and physical force to put in operation and to bring to their present condition the agencies which have wrought and still are working injury to these channels, and of which I have spoken. To counteract these the State must recognize that at least some considerable proportion of the same elements must be applied.

The tidal flow and the floods in the river.

Now, it may be asked, supposing that these results are obtained after some years of effort and expense, in what respect, other perhaps than in navigation, will the river community be benefited—*will the flood line be lowered?* If we admit the tide again to the upper reaches, will not the tide add to the height of the flood within reach of its influence? Does not the increased slope now existing promote rapid drainage of flood? To this may be answered, that the increase of slope

does add something to the velocity of drainage, but that is much more than offset by the filling of the stream.

The river section and slopes.

The increase of section in the rivers, the cleanness and smoothness of the channels promoted by the daily action of the tides, and the lowering of the slope, are all favorable to a low flood-line.

This is well illustrated in the lower section of the river, where the flood-slope is much less than in the section about Sacramento, as shown on the longitudinal river profile in this office. If this slope could be carried to Sacramento, the flood-line of 1879 would have been seven feet lower than it actually was at Sacramento.

Low slope of tidal rivers.

This low slope is found in the parts of the river least impaired by deposits, and preserved from these deposits by tidal action. In the ratio that the lower channel is blocked by deposits, so will the flood-slope be increased, and the floods above be heightened.

Importance of the conservative action of the tides.

The tide is, then, according to the view of this report, the salvation of the lower divisions of the river; and the extension of its influence, either by raising its level at any given point, or by extending its flow up the river, is so much gained in this general interest.

CHANNEL IMPROVEMENT—LOWER RIVER SCOURING ACTION OF THE CURRENT.

In the improvement of the Sacramento River channel, the most potent influence for general good must ever be the transporting power of the current in the stream itself, produced by the outflow of land drainage waters; for the beneficial effect of the tides will be confined to the lower division of the river, while this scouring force of the drainage waters gravitating to the sea is present throughout the length of the river, and only needs to be guided and concentrated to work industriously for the desired result.

Transporting power of currents.

Without entering here upon any discussion of the transporting power of running water, which is very generally recognized but very little understood, it is well to say that the observations made by this Department in the transportation of sediment and sands by the waters of the Feather and Sacramento Rivers show conclusively that, though at the lower stages of the streams, with the presence of a small mean velocity of current, there may be a greater percentage of solid matter held in suspension, yet, when the streams are high, the sediments carried are of a heavier character, more sandy in their nature. And, furthermore, it has been observed that during the full stages of the streams the bottom is one moving mass of sand.

Observations of the past season.

At Freeport, 14 miles below Sacramento, where the river was sounded and resounded 14 times in one cross section, carefully, over the same spots, during the highest freshet of the season, changes in mean depth of 1.5 feet in 24 hours were frequent, and the rule; while

on one occasion the mean depth in one cross section varied 2.64 feet, with a maximum variation for about 100 of the width of 6.5 feet in depth. And from the cross-sectional measurements of the streams, it has been found that where the waters, which are now confined below the mouth of American and above Grand Island in one channel, pass between banks about 450 feet apart, their mean depth is 12 feet below the low water line of 1878, as against a depth of 4.8 feet in widths of 900 feet; and that during floods the tendency is to raise the bottom in the wide reaches and scour it out in those of average width and in the narrow places, when scouring is going on at all.

Here is the evidence of the ability of the current to restore the channel and make it better than ever, if it had the opportunity—were freed from the load of sands constantly coming from above, and had its channel bars removed by proper treatment. It were useless to prolong this report by the citation of many facts as to the nature and extent of this class of phenomena observed during the past season; suffice it to say, that certain primary practical conclusions of fact are had, as follows:

Results of the observations made by this Department.

Where the channel is at a width duly proportioned to the amount of water it now habitually carries, we find depths of water which produce a well-formed cross-section; and furthermore, at such places the sands are carried up in the body of the current more than in the wider reaches, where they are rolled along the bottom.

Conclusions from these results.

These facts appear to show that confining the water to a channel of width bearing such a proportion to its volume as to cause a scour to the greatest depth possible, produces conditions in the filaments of the current favorable to the transportation of the heavier sediments.

Now, if these observations are not in error, and if the deductions are sound, then we have a key to the measure of scouring power we may expect should the river be run as full as could be carried between embankments of a safe height.

General treatment of the river channel.

It were idle at this time, however, to enter upon a discussion of just what this effect would be, even if the observations had extended over a sufficient length of time to be certain of our results (which they have not); for so long as there remains the constant supply of sand from above, the increase of scour in the lower river would only accelerate the advance of this injurious silt from the upper source. Of this we may be certain, however, that if the supply of sand could be stopped, these river channels could be very much improved within a few years, chiefly through the agency just discussed.

Process of channel improvements.

The process would be somewhat as follows—for the river below the mouth of Feather: We must suppose the water delivered at this point through channels from the Upper Sacramento and from the Feather, and not from the great Sutter basin, as much of it now comes. Why this must be, and how it may be accomplished, will be spoken of later.

With the corrections in the channel below, heretofore noticed, and

a similar treatment for several other shoals at points above the head of Grand Island, the stream would be of fairly good regimen; it would be in a condition to levee, and by raising the water surface force the scouring action without danger of washing out the material at one place in the channel only to deposit it at another, and thereby making a worse obstruction than there would be if it had been deposited more evenly down the bed.

Uniform system of leveeing.

Thus, were the levees of even disposition, uniform heighth, properly adjusted width apart, according to the flood volume to be carried, we would have a channel balanced in all its parts.

With these embankments five feet above the flood plane of 1879, 3.3 feet above that of 1878, from Feather River to the head of Grand Island, in the average their mean elevation would be 7.0 feet, or 3.0 feet higher than the average of the levee now existing on the east side of the Sacramento below that city to the lower point named.

Relief of the channel.

During the first years of the flushing of the channel such a levee would be liable to overflow by the waters of ordinary floods; but this must not be permitted, neither should considerable volumes of water be diverted at one point as a relief, for the conditions in the current favorable to the transportation of sediment would thereby be disturbed, and deposit would occur. But at many points, say every four miles along the way, located according to circumstances, to be studied attentively, there should be an escape weir capable of passing a maximum volume of 2,000 to 5,000 cubic feet per second, each opening into a channel between embankments leading back into Yolo basin.

Forcing the scouring action.

Now, so long as the river channel could pass all the water presented for transmission during any freshet, none should be allowed to escape; but the scouring power should be preserved at a maximum degree for the greatest period possible; but when there came danger of rupture or overthrow of any portion of the levee, the floodgates should be permitted to act sufficiently to ward of the evil.

The result to be expected.

It cannot be doubted that the result would be made manifest in a great increase in the capacity of the stream. The narrowest places would be widened, the bottom all along taken out, and if per chance a hard bar should be exposed that would not yield to the scouring action, it must be dredged out; if a bank cave so as to endanger the levee, it must be protected, and promptly, too.

Such is an outline of what is thought to be a proper treatment for the lower Sacramento. Further details at this time would add nothing to the practical value of this report. The principle involved is broad; river improvement, the "promotion of rapid drainage, the reclamation of swamp and overflowed lands" of this valley, requires organization, government of works, subservience of individual interest to public good.

TO PROMOTE RAPID DRAINAGE—LOWER FLOOD REGIONS—RECAPITULATION.

Works advisable on the lower river.

With the lights before me at present, it appears that much good can be effected, and great harm prevented by—

First—Turning Putah and Cache Creeks over the Montezuma Hills to a new outfall, through the Montezuma Slough.

Second—Removing the channel bars between Grand Island and widening the channel in the Horseshoe Bend.

Third—Opening a new head to Steamboat Slough, and making it the main flood-carrying channel of the river.

Fourth—Constructing an uniform system of levees higher than those now existing, with waste or flood escape weirs at short intervals of space, leading into the Yolo basin.

The sand flow must be stopped.

Always provided, however, that the sand flow from the upper streams be checked, that the whole drainage system is properly managed after the works are built, and that the upper valley drainage is regulated as hereinafter described.

Results from this treatment.

With this accomplished, very much of the Yolo basin would be exempt from flooding in all ordinary winters; for a comparatively narrow strip through the upper part would lead away all the flood that would get into it after a very few years, to the great sink at its lower end; and as the floods would always run down much sooner than they do now, such lands would dry out earlier in the season, for there would be no escape upon them except at the top of the flood flow.

The American basin would be exempt from overflow from the rivers, but would still receive the drainage waters brought down by Auburn Ravine and other creeks from the east. In the course of time this could be remedied by conducting these waters to the river, some around the head of basin, and some into the American at the lower end.

Grand Island, and others below it, would be no longer endangered by sudden eruptions of water from the Yolo basin upon them; for unless there should come such a great inundation as was presented in eighteen hundred and sixty-two, there would never be enough water got into the basin to produce anything more than a gentle flow from Cache Slough.

The river bank property, including the City of Sacramento, would be much more secure than it would be otherwise, for the river, though kept at a high stage, would have a regulator, so to speak, upon it, and with judicious management the danger of overflow would be reduced to a minimum.

The character of the relief to the channels.

It will be seen that the project involves the diversion of water from the river channel at time of flood, but it should be distinctly understood that the manner of diversion is entirely different from that where 20,000 to 30,000 cubic feet per second are taken out in a low grade canal at one point. And furthermore, it should be remembered

that the diversion is only proposed for the top of the flood; that it would only be a temporary mode of relief during the first years of the process of improvements; and that the whole aim and object of the work would be to make the river in the course of time carry all the waters of ordinary floods, in its own channel.

A final report impossible.

I regret that I am not enabled at this time to give an unqualified opinion that this plan will afford a speedy and complete relief from overflow. All that can be said now is that it will greatly better the existing state of affairs; that instead of becoming worse, there will follow a gradual but certain improvement in the drainage of the valley, and that in any event, if present tendencies are to be stopped, and the drainage ever to be perfected, very much if not all of what has been suggested must be done. In this connection I call your attention to the concluding paragraphs of this part of my report.

THE UPPER VALLEY DRAINAGE PROBLEM.

This problem has been stated as follows: To provide drainage-way sufficient to bring the waters of ordinary flood volume from the Upper Sacramento, near Stony Creek, through to the head of the lower region without overflowing or threatening the upper region of present floods.

By reference to the description already given of the river, it may be seen that above Butte Slough we find a channel of greater slope, dimensions, and capacity than below it.

The waters advance rapidly to the point spoken of, gorge the channel below, are thus backed up to high flood level, and cause inundations. True, they also overtop the banks or break existing levees between Princeton and Chico Creek, before the gorge, 25 to 50 miles below, is consummated; but then, as compared to the leveeing on the lower Sacramento River, there has never been anything done, except at limited localities, to prevent this.

Suppose even greater embankments would be required for the purpose than on the lower rivers, certainly if levees must be higher and stronger in one locality than another, it seems reasonable that when the greatest flood wave is presented, it should be dealt with by means proportioned to the necessities of the case, if such are practicable, unless relief may be had without increasing the burden to be borne elsewhere.

This latter exception is seldom the case; for in conducting flood waters down the valley, any acceleration in rapidity of drainage in its upper divisions, by precipitating the flood below, increases the momentary volume there, and necessitates more drainage way for its accommodation, else inundation will follow. This is particularly the case where, as in the Sacramento Valley, there are large tributaries joining the main stream, whose freshets arrive at the point of junction before the waters from the upper valleys get there. The first flood wave thus presenting itself to the main channel, should have all the time possible in which to move away before another is brought down upon it.

The only exception to the general rule discountenancing increase

in rapidity of drainage from the head of an alluvial plain when the stream below is deficient in capacity, is to be found where its waters can be conducted to a separate outfall; that is, not brought down to meet other floods. I have not been enabled to see how this can be accomplished from the Upper Sacramento, and hence conclude that the wise and just plan to follow will be to do all that can be done—construct works at least up to the standard reached elsewhere in the valley—to prevent the spread of the waters which cause so much injury below. When this is accomplished the floods will appear less formidable. I hope to have an opportunity hereafter of presenting much detail of fact concerning this problem, which would unnecessarily prolong this already lengthy report; for the present, the subject will be considered only upon the principles involved in dealing with the flood-waters and the river.

CHANNEL IMPROVEMENT ABOVE COLUSA.

From what has been said concerning the relative capacity of the river above Butte Slough or Colusa, and below those points, the importance of limiting the discharge from the upper divisions into that below, to as small a maximum quality as possible, will be readily recognized; the capacity below is already deficient; it will take time to increase it, therefore the waters from the above must not be unduly presented if possible to present it. The greater the storage room in the stream itself, above the point of least capacity, the less the maximum outflow from the upper divisions need be to prevent disaster to levees there. Hence above Colusa it is necessary that the levees should be far apart. Fortunately other circumstances contribute another argument for this disposition. The immediate banks of the river in this region generally do not afford a safe foundation for levees, for they are continually caving down, but a favorable locality is found in the hard plain lands which extend on either side of the river, at the distance of a mile or more from rim to rim. By placing the levees back on these hard rim lands, one great object of the work will have been accomplished; a large reservoir capacity attained above a portion of the river where the capacity to pass the water is comparatively small.

It has been stated that another object of work in this division above Colusa should be to prevent the too rapid passage of the waters to the division below.

The natural tendency of the river is continually to shorten its course by cutting across the long sinuous bends at time of high water, and then when it falls within banks, to increase its tortuous course by caving down the banks in the concave side of the bends, and so add to its length again. Thus at any one of the many different points a cut-off may at any time occur, which would shorten the route of the main volume of water from half a mile to two or three miles. The rate of fall is thus increased by shortening the distance between points; the resistance to onward flow presented by the sinuous course of the river is done away with at that locality, and a more rapid advance of the flood-wave is the result.

This result is just what is not wanted in the division under consideration, for the general good sought by a drainage system for the valley, hence it seems reasonable that cut-offs above Colusa should be prevented, and the river should be encouraged to increase the

sinuosities of its course, up to the point wherein the reservoir capacity in this division is brought to the highest figure in volume it can be put to without overtopping levees of safe and reasonable elevation and cost. Were the channel more crooked than it now is, it would be longer, and the storage capacity greater in it, the slope would be less, and hence it could be the more readily made navigable and kept so all the year round.

Upon this general plan the principal works essential above Colusa to Stony and Chico Creeks, will be:

First—A levee from eight to fourteen feet in height, on each side of the river; the two as far apart as the topography of the country and the character of the soil will admit, up to a maximum limit of two miles, with an average of about 1¼ miles.

Second—Protection of banks to prevent caving where the river manifests a disposition to make cut-offs.

Third—Encouragement of caving at points where it is desirable to increase the length or give a better trend to the channelway, and so prevent the formation of bars.

Fourth—Training the current to cut channels of moderate depth through the very shoal places, and so increase the navigability of the stream, and preserve its stability when desired.

Fifth—Production of a growth of timber and underwood on a large portion of the country between the levees, to hold back the flood waters, when above the natural surface of the ground, and so prevent a downward rush thereof by the short route across points, and the formation of cut-offs which would thus occur.

It may be thought well to divert waters from this channel, near the head of the division under consideration, and conduct it by a canal through the Butte basin or alongside of it to some other point on the stream below, and thus diminish the necessity for extended work along the river in this upper division.

After what has been said, a moment's reflection should lead us to recognize the fact that this would constitute one big cut-off—a cutting off of all the bends at once—for a part of the waters at least. If the principle is wrong in the one instance under existing circumstances, it is wrong in the other.

If the waters from the Upper Sacramento are brought to the river below sooner and in greater volume than they would come down through a natural channel of good regimen—even capacity to hold or pass the water as it is presented to it—the problem of drainage is rendered more difficult. The lower regions would be flooded for the relief of those above. And it seems reasonable, first, at least, to do all that can be done to prevent this result before it is deliberately sought after.

CHANNEL IMPROVEMENTS—COLUSA TO FEATHER RIVER.

While above Colusa, an object to be held in view under existing circumstances, is to prevent unnecessary rapidity of movement in the flood-wave, below that place the point of balance is passed, and thenceforward to the mouth of Feather, and, indeed, to the bay, it is necessary to assist in every way the carrying capacity of the channel in order that the waters may be conducted onward as promptly as they will be presented from above.

In the division below Colusa, or Butte Slough, rather, the channel

is extremely crooked and narrow. The fall is small compared to that above, as will be seen by the description given elsewhere.

In the 64.6 miles of the route from Butte Slough to the mouth of Feather, the fall in the flood line of 1879 was 29.15 feet. Of this fall about thirty to thirty-five per cent. was consumed in bend resistance. That is, if the channel were a straight one, or one of moderate and gradual curvature, the same amount of water would run through it with thirty-five per cent. less fall.

The importance of cutting off some of the worst bends in this region is here made apparent.

Aside from this line of treatment, to increase the flood slope and diminish bend resistance in this portion of the river, we may apply the expedient proposed for generally enlarging the capacity of the stream below the mouth of Feather, namely, thorough levying and working the channel up to its full capacity, without allowing the levees to be breached, for as long a time each season as the river will furnish the supply.

But above the mouth of the Feather greater obstacles are to be overcome in the scouring process than below, in the form of a harder bottom and banks more firm. So it is possible that the power in the running waters would have to be assisted by artificial excavations to a much greater extent than below.

Perhaps this channel would not at first carry all of the waters presented to it during the passage of the crest of the flood waves down the valley.

Admitting this, the period of time when it might not thus pass all presented would be short—three or four days at most—and for that time all in excess of the maximum capacity may be taken through the levees by means of suitable weirs, or flood-gates, and conducted in embanked channels to the low basins from whence it could be drawn out again so soon as the river would fall.

The Sutter basin, for instance, is now annually flooded. The water enters it from both ends, commencing with the first rise of the river each season, probably in November, and it is not drained until as late as July.

Quite frequently there is not more water presented to the river past these basins than it could readily carry until the end of January or middle of February, if treated as heretofore described.

This was the case in the season last past, the floods of which were observed by this department.

Yet the Sutter basin received water in December, 1878, was well filled in January following—six weeks before the highest freshet came.

And on only one occasion during the season—for seven days, from the 5th to the 12th of March—was there more water presented than this channel would carry in its present condition, if evenly leveed and the river below presented a good outfall, as it would if the system of works outlined for it were carried out.

Thus during the season of 1878-79 the real surplus waters of this upper river, had it been under treatment by the progressive system proposed, would not have filled the Sutter basin alone to more than about half the depth it was filled. The river would have run down much earlier in the season, and the water that would have been put into the basin could have been drawn down earlier in the season than it was under the order of things now existing.

It is respectfully submitted that even this would be a vast improvement to the present condition of affairs.

It would be an improvement for the basins themselves, because it would keep them free from water for a longer period each year, and because a larger portion of their lands could be cultivated during each such year as the past has been.

And it can not be doubted that the river would annually become more and more capable of carrying the waters brought to it, so that a complete immunity from flood during ordinary years might be looked forward to for all the low lands of the upper region.

Not only would this arrangement produce at once a great improvement over the present condition of affairs for the lands now annually flooded in the upper valley, but it would render possible a proper treatment of the river below the mouth of Feather, which could not now be undertaken, even with all other pernicious influences removed, if the Sutter basin remains open.

INFLUENCE OF THE UPPER VALLEY FLOOD-WATERS.

In the discussion heretofore entered upon concerning the relief canal, and again in considering a treatment of the lower river for its general improvement, I have spoken of how the water now flows at will into and out of this Sutter basin at its lower end. As it is now, the elevation of water in this basin governs the flood line in the Sacramento at the mouth of Feather River where the basin comes to an end.

Should the attempt be made to improve the lower river by a uniform system of leveeing and the treatment heretofore outlined, the flood line must be raised, temporarily at least, at this point. Were the Sutter basin open it of course must fill before this elevation could be obtained, and possibly to a higher level than ever before in ordinary years.

We would, under such circumstances, have a state of affairs about as follows:

A large portion of the waters of the earliest freshets of the seasons would be taken up in filling this reservoir, and meanwhile the river below could not be run full and the benefit of the scouring action obtained. Later would come a heavier freshet; much of the storage capacity of the basin would be by that time taken up; this new water—the first of the heavier freshets—would fill still higher the wide expanse in the basin, by entering as it does now from points above on the upper river, as well as at the lower end, and where the maximum volume of the flood—that only which the upper river could not pass readily to the mouth of the Feather—presented itself, the waters must rise still higher to give it room. Meanwhile the river below, until this highest point in the flood above should be reached, would not have been performing its full duty—for there would not be *head enough to force it* as long as the waters had the opportunities to spread.

Now, this vast volume of water, resting unrestrained immediately at the head of the lower river, and in open communication therewith, would be a continual menace to the region below, an impending evil which might at any time overthrow the best laid plans; for, were the levees up to a standard as to elevation and weight never so perfect, and amply sufficient for all ordinary flood contingencies in the river

proper, yet might a strong north wind, sweeping over the twenty-seven miles of this lake surface down to the head of the leveed portion of the river, pile up there such a volume of water to be carried away as would bring disaster to works and lands far below.

Something similar to this occurred in 1878. A large portion of the great flood-wave which overthrew the levees of Grand Island was blown out of the Sutter basin 59 miles above. Entering the head of the lower Sacramento from this basin, the flood line was raised at the point of junction about five feet in a few hours. This wave went down the river, caused breaches in the levees, and swept into the head of the Yolo basin, diagonally across which it coursed, running well up on the west rim, and making higher water there than on the east side at opposite points; thence, turning, it again crossed the basin and was projected out into the Steamboat Slough and the division of the river below, where it overthrew portions of all levees in its way, and destroyed property valued at hundreds of thousands, almost millions of dollars.

The primary cause of this mishap, of course, was the deficient capacity in the river at many parts of its course; but, setting natural causes aside, there is an important cause in the defective system of works in the upper flood region. Thus does the safety of property, the good condition of the river, and the welfare of the lower valley, depend upon efficient works in the upper valley. Unless the waters are kept from spreading from the river at will into the head of the Butte basin, and thence on down into the Sutter basin, there can be no thoroughly efficient treatment of the lower river, and no permanent security for works and property far removed from the seat of primary flooding.

I hope to have the opportunity of presenting facts in this and similar cases in a more definite form at some future time. At present the most important and the fundamental principles are sufficiently illustrated.

The present condition of affairs can be greatly improved. Very much land now annually inundated can be protected from overflow during any ordinary flood, through a proper treatment of the drains made by nature to carry away the waters, provided the whole system of works be under proper control, and authority be lodged in the right place to adopt such measures as may be necessary to construct and maintain the works everywhere in the valley to an equal degree of efficiency. When this is done a long step will have been taken towards the complete and rapid drainage of the valley, and this much wished for consummation will neither seem nor be so far in the distance.

SUMMARY OF CONCLUSIONS.

In closing this part of my report, for the purpose of bringing together what appear to be the important points in the whole matter of promoting the rapid drainage of the Sacramento Valley, I now summarize certain deductions already made, and add thereto others which will be more fully substantiated in what will be said hereafter under the head of "The Flow of Mining Detritus."

The channels deteriorating.

First—The valley rivers, already much deficient in capacity to

carry the waters of ordinary floods, are annually, in the most important divisions, becoming less capable of performing this duty.

The sands the primary cause.

Second—The great primary cause of this deterioration of the channels is the flow of sands from the cañons into which the mining detritus is dumped.

A bad levee system.

Third—The carrying capacity of the streams and their efficiency as drains has been greatly injured, and the problems of regulating the drainage of the valley have been much complicated by the injudicious location of embankments and uneven results of leveeing along the rivers.

The channels never large enough.

Fourth—The river channels never were capable of passing the water of ordinary floods through some of their divisions without material rectification thereof, and the attempt to confine flood-waters by the simple construction of levees without systemization and the aid of other devices to improve the channels themselves, could not have succeeded generally, even though the sand-flow had not come down the rivers.

Destruction of Steamboat Slough.

Fifth—The very existence of Steamboat Slough, an important branch of the river, as a navigable and flood-carrying channel, is threatened, as evidenced by its rapid filling within recent years.

The future of the lower rivers.

Sixth—In the natural order of things we may look for the serious impairment of the navigable qualities of the lower portion of the main river in the near future; the flow of sands from the supply already in the beds of the Feather, Yuba, Bear, and American Rivers will bring about this effect unless the lower river itself is treated to improve its regimen; and, in any event, this result would follow before the general good effect of the scouring action could be fel below the mouth of the American River, unless the river channel below that point were rectified.

Importance of restraining the sand-flow.

Seventh—The presence of sand in the upper rivers, whence it is liable to be brought down in quantities, impairs the confidence which ought to exist in the success of whatever plans may be projected to regulate and facilitate the drainage of the valley; and hence, it is doubly important to ward off the danger.

The sands now in the cañons.

Eighth—If the deposit of detritus in the streams were to cease at once, yet would it be necessary to restrain in the cañons, and in the tributary streams below the cañons, that which is already there, and stop the flow of the sands therefrom, in order that we may count, with any considerable degree of certainty, upon the efficiency and permanence of drainage works in the valley.

A remedy possible.

Ninth—This danger can be warded off, in a great degree, at least, without radical interference with existing interests.

Danger of delay.

Tenth—The restraint of the sands in the cañons, and in the deposits along and in the tributary streams below their cañons, admits of no delay. It is the first objective point in the restoration and improvement of the carrying capacity of the valley streams.

Natural tendency of the stream.

Eleventh—If this desirable result were measurably secured—if the flow of sands into the Feather and Sacramento Rivers was stopped—the natural action of the rivers, relieved in a great degree from the load they now have to carry, would be to excavate their beds, and gradually to work back to the regimen of twenty years ago.

The river channel.

Twelfth—The accomplishment of this latter result can be greatly hastened by engineering devices and works, and subsequent management thereof; and, under any plan, this treatment of the natural drains must form the chief feature of the scheme for providing rapid passage for the waters.

Extent of possible improvement.

Thirteenth—As it would have been eminently practicable to have improved the carrying capacity of the streams to a very great extent before they became injured by the sand-flow, so, as they are brought back to their former regimen, may their rectification and enlargement of capacity be carried far beyond that point.

Raising of the river channel.

Fourteenth—This filling of the main channels, though confined to the Feather River and the Sacramento below the Feather, does, by raising the flood lines at the junction of the two streams, reduce the slope and capacity of the Sacramento above the point of junction, causing greater overflow, and seriously complicating the problem of drainage in the upper valley.

Interdependence of works.

Fifteenth—The interdependence of works for the preservation of overflow throughout the valley has been so completely demonstrated by the mishaps and disasters of the past, that the solution of the problem of drainage here presented can only be hoped for when the work is carried forward with the one object of disposing of the waters as a whole, and not, as heretofore, for purposes of reclamation of separate parcels or districts of land, and therefore it is essential that those operations should be under one head.

Injury to valley lands.

Sixteenth—The direct injury to valley lands, caused by the flow of sand and "slickens" over certain large tracts thereof does not represent the measure of harm thus far done to the agricultural interest, for other lands are in danger of similar submersion; still others have

been rendered less fit for cultivation by having the flood lines raised in the adjacent streams so as to make them swampy in character, and the great body of the low valley lands has become less valuable, because more difficult of permanent reclamation, by reason of the injury to the flood-carrying capacity of the rivers.

Benefit to valley lands.

Seventeenth—On the other hand, however, there are lands in large bodies which, as they stand now, are more valuable than before the stream beds were raised; for, having been dry lands of poor soil, they have been rendered moist and tillable in a high degree by the raising of the sub-surface waters in them, which has followed as a consequence of the raising of the streams.

Keeping sands out of the cañons.

Eighteenth—Without doubt much of the mining detritus can be kept out of the main cañons, thus largely diminishing the quantity to be there reservoired, but how far this remedy, or preventive, rather, may be applied, can only be determined by special examinations of the various mining properties.*

Scope of the subject.

Nineteenth—This is a subject of great scope and importance directly, affecting the welfare and prosperity of a large portion of the people of the State, and the problems involved are of the gravest character, so that their solution cannot be arrived at, if fully worked out, even in a year.

Gradual treatment.

Twentieth—Remedial works can only be carried out by degrees, and the detail of treatment which the subject must receive can only be determined upon finally, as the partial results attained point out the way, and by such policy a satisfactory issue may be looked forward to.

RECOMMENDATION.

The State control of river works.

The study of this subject having brought me to a sense of the absolute necessity for organized effort in these matters, I can only recommend that the State take charge of the drainage ways and all drainage works, and exercise such control over them as will regulate their use, promote their improvement, and systematize the construction and management of all works designed to promote rapid drainage and prevent inundations.

Financial outlook.

As to who is to pay for the necessary constructions, it does not appear that any suggestions find a proper place in this report. I may remark, however, that nothing which has been said is to be interpreted as meaning that I see no way of accomplishing the desired end except by State work; on the contrary, while some of the devices necessary are certainly such as the State might with propriety, in my opinion, contribute towards, the great bulk of the work is

* The last conclusions will be illustrated in the report on Mining Detritus.

such as should be paid for by the property in the drainage district where waters are to be purified and conducted away. And it would seem strange, in view of the immense amount of property affected, if the necessary funds could not be secured by organized effort.

CONCLUSION.

In conclusion, I respectfully call attention to the circumstances under which this report is made. But little over a year has passed since the work of investigation was begun. The field of operations has reached from Shasta to San Bernardino, and extended over a third part of the State in area. Necessarily the results accomplished are largely preliminary in character.

I hope that the foundation is laid for an intelligent and thorough study of the great drainage problems which sooner or later must here be solved; that the steps taken in the matter of inquiry into the problems of irrigation—the results of which are to be submitted to you in a separate report—have been in the right direction to effect a solution of that problem, in a manner that will insure the greatest good to the greatest number, from the use of the waters.

The data so far obtained is now barely brought into form for study. The systemization of observations, the training of assistants in special duties, is but just accomplished, and the knowledge of localities and present conditions barely acquired.

With respect to the river phenomena of low and high water, the observations of one season have shown where it is necessary to observe more, and how to conduct the work so as to catch the items of knowledge necessary.

The condition of the rivers noted during one season must be overlooked the next, to ascertain what is going on and study the tendency of present influences. The general drift of influence may be ascertained in one season; but the measure of effect can only be appreciated by comparing the result of several seasons' work.

That which has been done is the most expensive part of the work on the field gone over; the practical results can be duplicated at half the expense, and the valuation of deductions quadrupled by the continuance of the work.

Thus it would be an act of vanity on my part, and certainly a responsibility which I am not prepared to take, to assume to report after so limited an examination, what purported to be final conclusions and recommendations as to details, or even general plans; more particularly, seeing that the law under which I have been called upon to act anticipates at this time only "a statement of the condition of the inquiry, a history of operations up to date, the important facts that have been ascertained, either accurately or approximately, and the deductions or recommendations which have been justified by the inquiry in regard to the principles which ought to govern in the irrigation of lands and the relief of the rivers when in flood, with such practical recommendations as the State Engineer may see fit."

CHAPTER II.

THE SAN JOAQUIN VALLEY DRAINAGE.

In what was said concerning the San Joaquin and Sacramento Valley floods, by way of introduction to this second part of my report, I have spoken of the very limited opportunity I have had to study the river problems of the San Joaquin.

No flood observations on the San Joaquin.

There really has been no opportunity at all of observing a high water in the San Joaquin—there has been none to observe—nor has there been any means at hand to fully collect the data of flood phenomena, though an effort was made, as explained in part one, to conduct some observations in June, 1879, which failed, however, because the waters did not rise.

Hence, though I would much like to do otherwise, I am forced to give the subject a very superficial treatment at this time.

Examinations and surveys on the San Joaquin.

Surveys and examinations have been extended up the San Joaquin and all its subsidiary channels, as far as the mouth of the Stanislaus, and no further. For this reason the data available will not admit of a full description of the field of overflow, as has been given in the case of the Sacramento Valley flood regions, and hence, no general description will be attempted. There are, though, some points of especial interest which are sufficiently understood to make possible a discussion of them, and, as they are important and of great local interest, I feel justified in undertaking it, at the same time reiterating the fact that it has not been possible to obtain the information necessary upon which to make definite statements. It is my intention, however, should I have the opportunity, to make this a special object of study during the approaching spring.

THE SAN JOAQUIN RIVER PROBLEM.

The river flood problem proper commences far above the region surveyed, for we have here very much such a case as is presented in the upper Sacramento Valley: a case where an upper division of the channel is larger and on a greater grade than that below, which habitually loses a large portion of its waters and has become contracted. Hence, for the relief of the lower division from flood, it is essential that the river above it be not treated so as to precipitate the floods upon the channel where it is of deficient capacity. It may be said that the San Joaquin River flood problem necessitates a study of the river as high up on its course as the point where its waters first escape from their channels in time of ordinary flood, and this point is above the mouth of Fresno Slough, and not far below the crossing of the Valley Railroad; for it is only there, for the first time in ascending, that a good gauging of volume in one channel can be made at time of flood.

The river problem in the Sacramento Valley.

In dealing with the drainage problems presented in the Sacramento Valley, but little has been said concerning the improvement of the rivers for purposes of navigation. The prevention of overflow, the preservation and enlargement of the channels to enable them to carry away the flood waters is, there, a pressing necessity, and in considering this subject it becomes apparent that the interests of internal navigation will be subserved by a treatment of the rivers to accomplish the prime purpose.

Moreover, the large volume of water habitually carried by the Sacramento renders its navigation, for freighting purposes, by the use of barges, comparatively a safe and certain highway.

The river problem in the San Joaquin Valley.

The San Joaquin, on the contrary, drains a larger extent of country, wherein the traffic is of a character which demands cheap water transportation, yet the river itself is of small volume (as compared to the Sacramento), and its channel presents many serious obstructions and inconveniences to the movement of boats. Furthermore, while this deficiency in navigation facilities is an ever present inconvenience, and a serious drawback to the welfare of the valley, inundations occur but seldom; the flood volumes are small for about nine years out of every ten; and when we view the situation in the two valleys, though it may prove to be comparatively an easy work to conduct away these San Joaquin floods without overflow, it must always remain a delicate work to establish and maintain the best possible conditions in the channels of this river for purposes of navigation, for the volume of water habitually carried by it is barely sufficient to admit of its successful treatment as a navigable stream.

Navigation the ruling consideration.

Hence, while we may treat the Sacramento altogether as a flood-carrying channel, and be assured of securing results favorable to navigation, the latter interest must be more carefully looked to in dealing with the San Joaquin, lest, in planning for flood relief, we seriously retard low water navigation and inconvenience that interest at all times.

Discussions in the preceding chapter.

The principles which should govern in the treatment of a river as a flood-carrying channel, are sufficiently discussed in other parts of this report, and in the preceding chapter I have spoken of the conservative action of the tides in the lower rivers. To avoid repetition I refer to these paragraphs, and here only make such applications of the principles brought out as appear to me necessary.

FLOODS FROM THE SAN JOAQUIN.

Causes of the ordinary flood disasters in the San Joaquin Valley.

With respect to inundations of leveed lands, it appears there are two immediate causes why these occur on the San Joaquin:

First—At the upper portion of the leveed region the floods rise and overtop the embankments before the waters can escape through the river channels.

Second—Towards the lower end of the leveed region the levees, or

the foundations upon which they stand, yield to the pressure of the water before the embankments are overtopped.

The cause of the first class of disaster is either that the flood volumes are presented with undue velocity and momentary amount at some points, or the channels are generally deficient in capacity between the embankments to pass the waters presented.

More data necessary.

To properly discuss this matter of flood volumes and channel capacities would necessitate much more data than are at my command, but enough is known to enable me to point out where and how both these last mentioned causes contribute to produce the overtopping of the levees which occurs at the upper end of the large leveed islands.

The following tables exhibit certain data obtained by the surveys of the river channels made under my direction, and, as far as it goes, the information is good of its kind. But it must be supplemented by flood observations before these problems can be discussed definitely.

SAN JOAQUIN RIVER.

Channel dimensions and grades in the several divisions.

Designation.	First Division—San Joaquin City to Paradise Cut.		Second Division—Paradise Cut to Old River.		Third Division—Old River to head of Burns' Cut-off.		Fourth Division—Head to foot of Burns' Cut-off.		Fifth Division—Foot of Burns' Cut-off to Twenty-one-Mile Slough.	
	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878
Distance from upper to lower station	13.8 miles.		5.8 miles.		13.2 miles.		4.7 miles.		7.5 miles.	
Elevation of upper station (above low water in the Bay)	19.00	29.25	9.00	23.35	5.60	20.15	3.35	12.15	2.50	10.0
Elevation of lower station (above low water in the Bay)	9.00	23.35	5.60	20.15	3.35	12.15	2.50	10.00	1.75	8.35
Difference of elevation between upper and lower station	10.00	5.90	3.40	3.20	2.25	8.00	0.85	2.15	0.75	1.65
Average slope per mile	0.72	0.43	0.57	0.53	0.17	0.61	0.18	0.46	0.10	0.22
Maximum slope for any five miles					0.19	0.65				0.31
Minimum slope for any five miles					0.15	0.56				0.04
Maximum slope for any one mile			0.80	0.65	0.20	0.67	0.20	0.49	0.14	0.60
Minimum slope for any one mile			0.15	0.47	0.14	0.53	0.16	0.44	0.07	0.03
Average width of channel		420.		340.		180.		150	300.	310.
Greatest average width for any one mile		550.		390.		210.		190.		340.
Narrowest average width for any one mile		260.		310.		160.		100.		280.

SAN JOAQUIN RIVER—Continued.

Designation.	Sixth Division—Twenty-one-Mile Slough to Middle River.		Seventh Division—Middle River to Old River.		Eighth Division — Old River to the Mokelumne.		Ninth Divisien—Mokelumne River to Three-Mile Slough.	
	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878
Distance from upper to lower station	10.2 miles.		4.8 miles.		1.6 miles.		6.6 miles.	
Elevation of upper station (above low water on the Bay)	1.75	8.35	1.00	8.22	0.960	8.200	0.947	8.193
Elevation of lower station (above low water on the Bay)	1.00	8.22	0.96	8.20	0.947	8.193	0.550	8.080
Difference of elevation between upper and lower stations	0.75	0.13	0.04	0.02	0.013	0.007	0.397	0.113
Average slope per mile	0.07	0.01	0.008	0.004	0.008	0.004	0.060	0.017
Maximum slope for any five miles								
Minimum slope for any five miles								
Maximum slope for any one mile								
Minimum slope for any one mile								
Average width of channel		410.		1,600.		1,800.		
Greatest average width for any one mile		510.		1,900.				
Narrowest average width for any one mile		300.		1,200.				

OLD SAN JOAQUIN RIVER.

Channel dimensions and grades in the several divisions.

Designation.	First Division—San Joaquin to Middle River.		Second Division—Middle River to Tom Paine Slough.		Third Division — Tom Paine Slough to Mohr's Landing.	
	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878
Distance from upper to lower station	4.2 miles.		3.9 miles.		9.3 miles.	
Elevation of upper station (above low water on the Bay)	5.60	20.15	4.95	18.00	4.20	16.20
Elevation of lower station (above low water on the Bay)	4.95	18.00	4.20	16.20	2.97	11.60
Difference of elevation between upper and lower station	0.65	2.15	0.75	1.80	1.23	4.60
Average slope per mile	0.15	0.51	0.19	0.46	0.13	0.50
Maximum slope for any five miles					0.15	0.60
Minimum slope for any five miles					0.07	0.35
Maximum slope for any one mile					0.23	0.75
Minimum slope for any one mile					0.05	0.32
Average width of channel		180.		100.		120.
Greatest average width for any one mile		200.		105.		150.
Narrowest average width for any one mile		150.		90.		90.

OLD SAN JOAQUIN RIVER—Continued.

Designation.	Fourth Division—Mohr's Landing to Italian Slough.		Fifth Division—Italian Slough to Connection Slough.		Sixth Division—Connection Slough to main river.	
	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878	Low Water, 1878	High Water, 1878
Distance from upper to lower station	11.3 miles.		15.4 miles.		10.0 miles.	
Elevation of upper station (above low water on the Bay)	2.97	11.60	2.30	9.45	1.42	8.00
Elevation of lower station (above low water on the Bay)	2.30	9.45	1.42	8.00	0.90	
Difference of elevation between upper and lower station	0.67	2.15	0.88	1.45	0.52	
Average slope per mile	0.06	0.19	0.06	0.09	0.05	
Maximum slope for any five miles		0.25				
Minimum slope for any five miles		0.12				
Maximum slope for any one mile		0.27				
Minimum slope for any one mile		0.10				
Average width of channel		100.		300.		780.
Greatest average width of channel		110.		410.		820.
Narrowest average width of channel		95.		200.		625.

FLOODS AT THE HEAD OF THE LARGE ISLANDS.

The main flood region of the valley.

The Stanislaus River enters the San Joaquin from the east, at the head of what may be called the main flood region of the valley.

Above this point there have been, almost annually, inundations of a region of country generally a mile or two in width, and in exceptional flood seasons the waters spread over a much greater area.

But a few miles below the mouth of the Stanislaus, the greatest expanse of what has been known in the State as swamp and overflowed land commences, and extends to the Sacramento Valley delta islands heretofore described.

The large islands.

Roberts and Union Islands are the two principal tracts of this great body of swamp. They lie alongside of each other, in the midst of the wide expanse, being formed by the division of the San Joaquin River into three branches, called Old River, Middle River, and Main River, respectively.

These two islands are partially reclaimed, having levees entirely around them. They spread out across the body of swamp sixteen miles in combined width, and stand in the way, as it were, of the movement of the floods down the valley, for, before they were leveed, the waters moved over their surface in broad sheets, and were drained away by sloughs which join the river at or near the lower end of the islands. Since the leveeing of these islands, however, and of the main lands east and west of them, it has been found that the flood waters rise higher in the channels than they did formerly, and they have frequently overtopped and breached the embankments along the head of Union Island, as well as at other points. It is proposed to inquire somewhat into the causes of these floods.

Observations at San Joaquin City.

A point called San Joaquin City is situated on the river, one mile west from the mouth of the Stanislaus in a straight line, and two miles below it by the course of the channel. There was a river gauge rod at this point, and some flood marks were ascertained, so that the slopes, etc., will be given from it.

San Joaquin City to Old River.

From San Joaquin City to the head of Roberts Island the river pursues an exceedingly tortuous course; the distance by the channel being 19.6 miles, while in a line following the general direction, from point to point—bearing north 19° west—the distance is 10 miles. Thence the main channel runs northerly.

Old River.

The head of Roberts Island lies in the forks of the Main River and Old River. The last mentioned channel leaves the Main River about at right angles to its general direction, and pursues a very winding way across the heads of Roberts and Union Islands. From this place of leaving the main channel to Mohr's Landing, a point on Old River, the distance is 10.6 miles in a straight line, on a course S. 85° 30′ W., and the channel is 17.4 miles in length.

Old and Middle Rivers.

Near Mohr's Landing, Old River turns northerly along the west side of Union Island. Middle River leaves the Old River channel about 4.2 miles from the head, and runs for about four miles northerly between Union and Roberts Islands, and thence pursues a westerly and northerly course to the main river, 15 miles below.

The region above Old River.

From this it will be seen that the main river above the head of the islands, and the Old River across the head of the islands, lie on the two sides of a great body of country, triangular in shape. The hypothenusal line across any portion of this triangle is, of course, shorter than the distance round by the two sides, following the general direction of the river, and when it is considered that the river itself is exceedingly crooked, it will be appreciated at once that the straight line across is very much shorter than the crooked channels around.

Adjustment of bank elevation.

Previous to the occupation of the country and leveeing along the rivers the bank elevations were built up and adjusted to grades made principally by the flow of water in the channels, and its spread each way therefrom; for the waters generally were retained in the channels above the head of Old River, except as they ran in thin sheets over the banks.

Effect of the crevasses.

Of late years certain large crevasses have occurred on the west bank of the main river, at points between San Joaquin City and the head of Old River, and large volumes of flood-water now escape by them each season, and pursuing the short route on the diagonal line, of comparatively heavy grade, across the great triangular shaped body of land before referred to, are precipitated into the Old River channel at about a right angle to the general direction of its course. There, finding a channel insignificant in size, exceedingly tortuous in alignment, and of small grade compared to the route by which they have come across the country, these waters are checked; they form a wide lake, with the Union Island and Roberts Island levees for the northern shore thereof, and the high plain lands bordering them on the south and west, for the shore on that side.

Overtopping of the levees.

Under these circumstances disaster is almost inevitable. Not having a line of escape equal in capacity to that of supply, the waters continue to rise against the levees, and ultimately overtop them. This result is sometimes hastened by the occurrence of a strong south wind, which, sweeping across the shallow lake for several miles, causes a surf to beat upon the levees or raises the water over them.

The large crevasses.

Three principal crevasses in the left bank of the San Joaquin, between San Joaquin City and the head of Old River, allow the escape of its flood-waters into the basin. The first, at Kassons' Cut, 3.1 miles below San Joaquin City; the second, just below Kassons' Landing,

7.1 miles; and the third, at Paradise Cut, 13.8 miles below San Joaquin City.

Flood-flow through the crevasses.

From the opening at Paradise Cut, the flood-waters, flowing over the bank of the cut—21.6 feet above datum—towards the portion of Old River comprised between the head of Middle River and the mouth of Tom Paine Slough, pursue a general direction across the basin varying between the limits of north 41° west and north 65° west, following the ground's slope, which varies from 0.79 to 1.13 per mile, whereas the slope by the river is, at flood stages:

From San Joaquin City to Paradise Cut, 0.43 feet per mile.

From Paradise Cut to the head of Old River, 0.55 feet per mile.

From the head of Old River to the head of Middle River, 0.61 feet per mile.

From the head of Middle River to Mohr's Landing, 0.48 feet per mile.

From the head of Middle River down its channel to Kidd Ranch levee, 0.40 feet per mile.

From Paradise Cut to Middle River, 0.54 feet per mile.

From Paradise Cut to the mouth of Tom Paine Slough, 0.52 feet per mile.

The flood-waters, leaving the upper crevasses at Kassons' Cut and Kassons' Landing, flow across the basin in a general direction north 25° to north 33° west as far as a point opposite Paradise Cut, and thence north 57° west to the mouth of Tom Paine Slough, following the grade of the basin from 1.33 to 1.45 feet per mile; whereas this is, by the channel, from the head of Middle River to Tom Paine Slough, 0.46; from Tom Paine Slough to Mohr's Landing, 0.50 feet per mile.

The crevasses should be closed.

In view of these facts, I am of the opinion that either there must be a much greater capacity provided in the channels of Old and Middle Rivers from and below the point of junction, and the levees along the heads of the islands must be made much higher and stronger than they are at present, or the crevasses in the banks of the main river above must be closed, to give any assurance of the prevention of the disasters which occur to the island property. And, even if the island levees could be made to resist this flood which is precipitated upon them, there must always result the wide-spread inundation of the lands south of the islands and west of the river, if the crevasses are left open.

Effect of the crevasse discharge.

This unregulated escape of waters from the main river through the crevasses, and their rapid passage across the country to the Old and Middle River channels, disarranges the regimen of the whole flood movement, and it cannot be expected that any plan of reclamation in the San Joaquin Valley for the region below the mouth of the Stanislaus can be made to succeed as long as it is permitted.

Alternative plans for improvement.

If the main river and its branches below the point of this escape are not of sufficient capacity to pass the ordinary floods that are

brought from above, then, either their channels must be enlarged, or water must be diverted from them in a regular and systematic manner. If water is to be permitted to escape to the west, it must be taken in a channel along the edge of the high land, on a grade approximating a mean between that above and below, and brought to the Old River channel at a point about two miles above Mohr's Landing. It should not be permitted to run down the steep slope of the country by the shortest route to the heads of the islands, because it will be very difficult to provide way thence for its prompt passage onward.

Old and Middle Rivers.

Now the Old and Middle River channels are very much contracted and very tortuous in their alignment. Old River can be greatly improved without material interference with existing works, but Middle River, near its head, cannot, for the levees stand close upon its banks on each side.

The leveeing already done.

There has been a most shortsighted treatment of these rivers of the San Joaquin near the heads of the islands. The channels themselves are narrow, and the levees have been built almost as close to the banks as they could be placed. This is notably the case on each side of Middle River near its head, and on each side of the main river for about eight miles below the point of division.

Effect of the leveeing.

Thus, here are two of the lines of escape for the floods restricted in capacity as much as they could well be. While the third line—Old River below the head of Middle River—an exceedingly irregular and contracted channel in itself, is called upon to carry the great volume of floods precipitated upon it by the rush of waters across the country, which could readily be carried away in the channels, in due proportion, if they were treated aright.

The levees should have been set back.

There was no good excuse for placing these levees where they are, except the lack of system in the general treatment of the whole subject; and it is but just to say that those who now control the works are not, as a general thing, responsible for the results of this lack of foresight. The banks, in the location spoken of, were firm, and did not slope away from the edges of these channels so rapidly that the levees might not have been set 150 to 250 feet further back on each side. Had this been done, and the space outside the levees cleared of undergrowth, there would not now exist a condition of things which it will be difficult to remedy without sacrificing works already constructed.

CHANNEL IMPROVEMENT.

Old River.

The Old River channel should be very much straightened and enlarged across the head of Union Island, and at some points on the west side of the island also. This work has been commendably begun by the present owner of the adjacent property; but it certainly seems that an improvement, in which the whole flood region is interested, should not be left to local private enterprise.

Main River.

The aggregate carrying capacity of these channels can be greatly increased also by improving the waterway of the main river at five or six notable points within the first five miles below the head of Roberts Island, where it has some very sudden turns; not by making cut-offs in all instances, but by reducing the rate of curvature, by causing the points to cut and the bends to fill, through a proper use of spur-dikes. This will not interfere greatly with the present levee system, and is the least that can be done here for the rectification of the evils. And again, there should be a certain straightening of the channel on the east side of Rough and Ready Island, where the main river divides for a short distance, as hereafter explained in some remarks made on the subject of improving the navigation of the stream.

General system necessary.

Here, again, is an instance similar to those cited in the Sacramento Valley, wherein organization extending over the whole field is essential to achieve success and prevent injustice; for the works necessary to relieve this flood region are largely those which should be undertaken at the expense of wide areas of country, embracing many reclamation districts, and it cannot be expected that there will be a unity of opinion and action amongst all concerned unless there be some organization under State supervision. Of course, those persons most interested might combine upon some general works which would accomplish much good, but they would be bearing burdens not justly their due.

FLOODS AT THE LOWER END OF THE LARGE ISLANDS.

Yielding of the levees.

It has been said that the disasters which have occurred at the lower end of the large islands and upon other similar island property in the neighborhood, have been occasioned generally by the levees or their foundations yielding to the pressure of the waters during flood stage in the spring.

Waterway sufficient.

This is not the result of a lack of cross-sectional waterway in the channels to pass the land drainage brought from above. Indeed, if the size of these lower river channels was regulated by the volumes of the land drainage waters alone, they would be insignificant as compared to what they now are, as described in the first chapter of this part of my report. The tidal action regulates the size of the rivers, in the regions where the levees give way from lateral pressure, and it would take embankments but little higher than those which have been constructed generally around the islands in the San Joaquin delta to form sides to the great natural drains high enough to insure the passage of the floods, if only those levees could be made to stand.

The lower river problem, one of levee building.

There is no doubt but that all ordinary floods can be carried away through existing channels below Rough and Ready Island, and a point on Old River at a corresponding distance from its mouth,

between embankments of moderate height, if those structures can be made to resist the lateral pressure of the water. This flood problem, then, resolves itself into one of levee building—how to build a levee on an unstable foundation with the material which is at hand. And this opens up a separate and distinct subject, which I hope to have the opportunity in the near future to consider, but which the time now at command will not permit of my doing justice to, though much instructive and valuable data is at hand for use as matter in the discussion.

Levees must be sunk to stable foundations.

It may be said, though, that the plan followed under nearly similar conditions in older countries, has been to sink the levees through the yielding super-crusts to the hard sub-strata, and that such experience as has been had here goes to prove this to be the true course to pursue; and at any rate I am of the opinion that this is the only plan which will prevent disaster, and that the greater portion of the material for levee construction on these lower islands must be obtained from the bottoms of the channels by means of dredging machinery in some form, and I believe that the time will come when all leveeing in the lower islands will be carried on upon this general plan. There are substitutes which will be temporarily effective, and as such are worthy of consideration and adoption in some cases, but from which no permanent good can be expected. These will be discussed at length hereafter, together with the whole subject.

IMPROVING THE NAVIGATION OF THE SAN JOAQUIN RIVER.

In the first part of this chapter I have spoken of the importance of treating the San Joaquin River to improve its navigation; and in the preceding chapter will be found some discussion as to the method of improvement of the tidal compartments of rivers.

Tidal action in the San Joaquin.

The San Joaquin, below Stockton channel, is eminently a tidal river, and all that has been said heretofore concerning the beneficial effects of the tidal action, and the methods of increasing these effects, applies with full force here especially, though much good may be accomplished for the channel as far up as the head of Old River, by a careful treatment and guidance of the same great agent.

The main river below Old River.

From the upper end of Old River—in point heretofore also spoken of as the head of Roberts Island—the main river pursues a course in general direction north 50° east to the head of Rough and Ready Island, 9.2 miles by a straight line, and 13.2 miles by the meanderings of the stream. Here the channel again divides, the main river turning to the right, and what is known as Burns' Cut-off to the left. From the head to the foot of Rough and Ready Island the distance, in a straight line, is 2.2 miles; by the main river it is 4.7 miles, and by Burns' Cut-off 3.7 miles.

Stockton channel.

Stockton channel, a tidal arm during low-water stages, joins the

main river channel from the east 0.85 mile below the point of division in the river at the head of the island, and during flood stages of the streams brings down a portion of the waters of the Calaveras River, whose proper mouth is at a point about two miles further down stream.

The main river below St. Catherine's.

The main river channel past Rough and Ready Island—particularly below the Stockton channel—is exceedingly crooked, and for its upper half very narrow. From the foot of Rough and Ready Island the river extends in a general direction of N. 55° 30′ W. for a distance of 12.7 miles by a straight line, or 22.1 miles by the channel, to the lower point of junction with Old River, being joined by the Middle River channel in the sixteenth mile. As it will be seen by the considerable difference between the distance over this route in a straight line and that by the channel, the river is exceedingly crooked, but it rapidly widens out from 280 feet at the head to a broad estuary 1,800 feet across at the lower end of this portion of its route.

Navigation on the San Joaquin.

The navigation of the San Joaquin below Stockton is most important, for this place is the great interior grain mart of the State. And the river above might afford a line of passage for the heavy freights and produce of the largest body of agricultural lands on this coast, which, if ever brought to a high state of cultivation under irrigation, will demand cheap water transportation. Even now this upper San Joaquin freighting is a business of large proportions for six to ten weeks each spring, while the waters are high from the effects of the melting snows; but the wretched condition of the channel above the head of the islands stops boating before the supply of water really fails.

Tidal influence in improving the San Joaquin.

On the lower river, below the head of Roberts Island, the improvement of the navigation of the channel must be accomplished by assisting the tidal scour, which, as explained heretofore, is capable of greatly improving channels under similar circumstances. We have not now in the San Joaquin the sand-flow to contend with, as spoken of in connection with the lower Sacramento river improvement, though the time may not be far in the future when here, too, will arise the same troubles from a similar cause.

Character of channel rectification.

But the tidal movement is very much impeded by the various sharp turns, acting as partial dams, which the channel takes, and the removal of these obstructions to the free swell and ebb of the waters is essential to the success of any treatment of the stream to improve its navigation.

Location of necessary improvements.

The chief location for rectifications of this kind is in the two miles of distance next below the Stockton channel, where four cut-offs should be made, reducing the length of channel way from 4.7 miles to 3.6 miles of distance. There should also be a similar rectification at the head of Rough and Ready Island, and as before noticed, sev-

eral others located within the five miles next below the head of Robert's Island. Studies in detail of the exact extent and effect of these works will shortly be completed, upon the large-scale detail maps in this office.

Channel improvement above Old River.

While, below the head of Robert's Island and the point of division of the stream the channel should be straightened, at least where the most abrupt bends exist, as far down as the broader and more commodious river below Rough and Ready Island, and, while it would be well that this portion of the river be widened materially, as a flood-carrying channel, by setting the levees back further, above the point mentioned, the reverse order should be the rule.

Comparison with the upper Sacramento.

This is a case in every respect similar to that explained more fully in speaking of the upper Sacramento channel improvement. The San Joaquin changes character at the head of Old River, very much as the Sacramento does at the head of Butte Slough. The river above is wider and on a greater grade than that below, is more irregular both as to width and depth, and has less stable banks.

Character of improvements above Old River.

To improve the upper river for navigation it will be necessary to bring it to a low water width proportioned to the volume of water it habitually carries as the result of land drainage, for it is for the most part beyond the reach of the tides. This will necessitate contractions of its channel at the wider places to a width about uniform with the narrow points, so that the water will preserve a uniform depth. Such results are best accomplished as a general thing, by means of spur-dikes, as heretofore spoken of, but arranged so as not to project the contents upon the opposite bank, and cause cutting away at those points.

Prevent cut-offs above Old River.

And again, the longer the course the water is kept in, the less will be its gradient and the greater the depth of flow at the low stages; thus, aside from the fact that shortening the stream above the head of Roberts Island would tend to precipitate the floods upon the contracted channels below, the interests of navigation at all stages, except when the river is full, demand that it shall be kept at least as long as it is now.

Effect of the crevasses.

And, furthermore, the escape of waters from this river during floods, as described, through the crevasses on the west, must tend strongly to produce silting in the main channel below them, and however gradual and imperceptible this may be now, the effect will be disastrous in the end.

TO CONCLUDE,

I am of the opinion that to insure against flooding in the island region and improve the navigation of the river:

First—The crevasses known as Paradise Cut and Kasson's Cut, as well as others of smaller dimensions on the same side of the river between San Joaquin City and the head of Old River, should be closed.

Second—The river, from the Stanislaus down to the head of Old River, should be brought to near uniform width in the low water channel, and leveed throughout on both banks.

Third—That cut-offs should not be permitted above the head of Old River, but should be made in a number of places below that point.

Fourth—The Old River channel should be much straightened and enlarged across the head of the islands.

Fifth—The whole treatment should be directed to improving the main river and the Old River channels, as presenting great advantages over the Middle River; and the general treatment should be similar to that recommended for the Sacramento River.

And I believe, with a judicious system of works, the prospect is more favorable for the entire prevention of disasters to the levees, during all flood seasons except such as 1862, in this region than it is in the Sacramento Valley.

Very respectfully submitted.

WM. HAM. HALL,
State Engineer.

REPORT

OF THE

STATE ENGINEER

TO THE

Legislature of the State of California--Session of 1880.

Part III.

SACRAMENTO:

STATE OFFICE : : : : J. D. YOUNG, SUPT. STATE PRINTING.

1880.

PART III.

THE FLOW OF THE MINING DETRITUS.

The Effects of the Flow of Mining Debris.

Mining Detritus and the Valley Rivers.

Mining Detritus and the Valley Lands.

REPORT.

INTRODUCTION.

To the Honorable the Senate and Assembly of the State of California:

In the law under which I am called upon to make this report, are embodied certain instructions applying directly to an investigation of what is popularly known as the "Debris Problem." This part of my report is made in compliance with those instructions, which are as follows:

Specific instructions in the law.

(I.) "The State Engineer shall also inquire into the question of the flow of debris from the mines into the watercourses of the State."

(II.) Ascertain "the relation which hydraulic mining bears to the navigation of rivers, and their carrying capacity."

(III.) Ascertain the amount and value of agricultural lands and improvements which have been covered up or injured by the overflow or deposit of debris coming from the hydraulic mines in the Sacramento Valley.

(IV.) Devise a plan whereby the injuries caused thereby can be averted, without interfering with the working of such mines.

Other instructions in the law.

Under another heading, as it were, and coupled with instructions relating specially to an inquiry into what may be called the Problems of Drainage, viz.: the matter of preventing inundations and improving the navigation of the large rivers, other specifications are found which cover a portion of the same ground, as follows:

"It shall be required of the State Engineer:"

(I.) "To ascertain whether there has been any change in the height of beds of the navigable rivers of the State, and, if so, to determine as nearly as may be the extent of this change, and the cause or causes to which it is due, and whether change is now taking place in the height of the bed of the rivers, and, if so, what legislation, if any, will be effectual in preventing the rise of the beds, or in diminishing the rate of the rise."

(II.) "To ascertain the effect of any change in the bottom of the rivers on the carrying capacity and height of floods in the rivers."

The two sets of instructions.

The specifications first quoted are the most definite. They point immediately to a probable cause for the effects spoken of by the other instructions as possibly existing.

As it now turns out, but one report is required to cover the whole ground for discussion. The agency admitted in the first set of instructions, as above quoted, has wrought changes in the heights of the beds of the navigable rivers, and has diminished their carrying capacity. Hence, I report upon the extent and effect of these phenomena under the heading of the present part, viz.: "The Flow of Mining Detritus"

A Treatment of the Subject.

The treatment of this subject is naturally separated into two distinct divisions:

First—An account of the effects of the flow of mining detritus;

Second—A discussion of the possible remedies for past effects, and measures for the prevention or mitigation of damage in the future.

The effects of mining detritus.

The effect of the flow of mining detritus into the streams is first made manifest by the raising of the beds of the streams, the consequent overtopping of levees designed to limit the spread of their floods, and the inundation, by water heavily charged with sediment, of the adjacent low lands, upon which a large portion of this sedimentary matter is deposited to their detriment for agricultural purposes. The harm done by the flow of this detritus is of a dual nature:

First—Injury to the streams of the State, into which it finds its way, by diminishing their capacity as flood-carrying channels, and restricting their usefulness as highways of internal commerce; and,

Second—Damage to the property of private individuals, by depositing thereon a soil not immediately susceptible of profitable cultivation, covering, destroying, or damaging improvements and personal property, or, by the disarrangements and contractions of the lines of drainage, rendering agricultural lands and municipal property subject to overflow, and necessitating the expenditure of large sums of money for their protection.

With a view to the nature of these effects, I shall report upon this, *first*, branch of the subject, under the following headings:

(*A*) *Mining detritus and the valley rivers.*

(*B*) *Mining detritus and the valley lands.*

And in so doing I shall not overlook the fact that there are good as well as bad effects of the sediment to be noticed.

The remedies for the sand flow.

In the second division of the treatment of the whole subject, I shall endeavor to point out some lines of action, and suggest some measures "whereby the injuries caused, can be averted without interfering with the working of the mines," and "be effectual in preventing the rise of the river beds, or in diminishing the rate of rise."

The investigation and its conduct.

Before proceeding to these duties I must, in justice to myself, say that the time allotted for the performance of the works imposed upon the State Engineer, has not been sufficient in which to accomplish nearly all of what may be expected of him. I hope it will be remembered that it is not alone this one subject which has demanded attention; that the inquiry has extended over a broad range of country

where this question is not presented; that the field of labor has extended into the far south of California; that an acquaintance, simply, with the localities to be considered would necessitate months of rapid travel and industrious examination; and that of the subjects to be studied and reported upon, this concerning the flow of detritus from the mines, is not mentioned in the first and main instructions embodied in the law, but only finds place in the after part thereof, in a subdivision of a section and subordinate to the main objects held in view by the statute, which are, according to Section 3, the investigation of "the problems of irrigation of the plains, the condition and capacity of the great drainage lines of the State, and the improvement of the navigation of rivers."

CHAPTER I.

EFFECTS OF THE FLOW OF MINING DEBRIS.*

MINING TAILINGS.

The substances placed in the cañons of the mountains and streams or ravines of the foothills in the prosecution of mining industry, are exceedingly varied in character. When they have been submitted to the action of water during the processes of removing and extracting the precious metal, and thrown aside in a heap or pile, they are all indiscriminately called "tailings." In form, dimensions, and general character, the individual pieces of these tailings range from the rock boulder of one or two cubic feet in bulk, down through the succeeding gradations of smaller bowlders, cobble stones, large and small gravel stones, coarse and fine sand granules, flakes, and impalpable powdery particles of minerals, vegetable soils, and other substances.

The movements and actions of the detritus.

When subjected to the action of running waters, causing trituration or pulverization by grinding and abrading movements amongst the pieces, there is a constant tendency in this mass of material for every piece to become smaller and partake of the grade next below it in point of size, and at the same time larger masses are worn away, producing at once a great addition to the bulk of the finest grades of the materials, viz.: the sands and finer sediments. These pieces and particles of varying specific gravity and stability, under the action of extraneous forces, are for the most part carried or rolled away from their original point of deposition. The finer sediments are transported through the river channels (when the waters remain in them and do not spread), and, speaking in a general way, the finest go out to sea and those next in grade are deposited in the bays—upon the flats around their margins. And so as we proceed up the line of travel over which the waters run from the tailing banks, we will, of course, as a general rule, find heavier pieces lodged in the channel, until we come to the dump, where lie the largest bowlders, scarcely moved perhaps from the place of their settlement on emerging from the mining flume.

The examinations made.

In Part I of this report will be found a brief account of what has been done in studying the action of these deposits; and their extent

* It is believed that the word *debris* applies to the mass of matter ejected from a mine upon a dump pile wherever situated, but the word *detritus* is more applicable to the sands and sediments which are swept away therefrom by the floods and scattered throughout the country below. The effort has not been made in this report to be precise in the use of these words. *Debris* has become popularized, and is used herein sometimes where *detritus* would be more applicable, no doubt.

and nature and further details concerning these studies are given in the appendices to this part, in the form of special reports, to which attention is asked.

I have, on the preceding pages, outlined the general tendency of effect consequent upon the flow of detritus from the mining streams, and have classified these effects as those pertaining immediately to the great rivers of the valleys and those bearing directly or indirectly upon property—agricultural and municipal—adjacent to these rivers and their tributaries.

I now submit a statement of such facts in relation to these matters as I have been able to ascertain and substantiate, remarking that in all such subjects there is a wide margin for variation, and that extreme views, opinions, and renditions are to be avoided.

MINING DETRITUS AND THE VALLEY RIVERS.

The bad effects of all kinds in the rivers and along their borders, due to the flow of mining debris, are caused by the sands. By reason of the considerable specific gravity of the granules they are not carried in suspension and transported through to the bays and to the ocean, but are rolled along the bottoms of the channels and lodged in the deep holes thereof, and wherever from any reason the currents are not strong enough to keep them moving forward.

Thus the plane upon which the river waters run is raised, natural channels are obliterated, levees are overtopped, lands inundated, and the finer sediments, as well as sands, are deposited thereon. These sands, then, which lodge in the beds of the streams constitute the cause of damage.

In a paper upon the Drainage of the Valleys and the Improvement of the Navigation of Rivers (Part II of my report taken as a whole), at pages 30 and 31 of the printed copies thereof, will be found the following statements on this subject, which I produce here, as a fitting announcement at the opening of the recital of facts in the matter.

Raising of the river beds.

It is quite certain that the bed of Feather River, and that of the Sacramento, below the point of junction with the Feather River, has been greatly raised during the past 30 years, and that since 1862, when sands were brought from the upper cañons in great volume, the rate of filling has been more rapid than prior to that time.

The raising of a bed of a river is first made apparent by the increase in elevation of its low water plane or level, the movement of which is a fair indication of the average filling on the shoals of the channel. Thus the Sacramento may have reaches of five to ten miles in length, of water 15 to 40 feet in depth, and the low water plane will be held in position by the shoals, which act as partial dams. There is abundant evidence to show that this was the character of the channel below the mouth of Feather River, in the early days of its navigation. Now we find these deep reaches, in great measure, filled up and the shoals raised, as evidenced by the increased elevation of the low water plane. Feather River, though less decided in its character formerly as a deep channel, has nevertheless been greatly filled, particularly at and below the mouth of the Yuba.

Elevation of the low water plane.

The low water plane of these rivers has been raised about as follows: Sacramento River, head of Grand Island, 1½ to 2½ feet; Sacramento, 5 to 5½ feet; mouth of Feather, 3 to 4 feet; Knight's Landing, 1 to 1½ feet. Feather River, Nicolaus, 3 to 4 feet; mouth of Yuba, 13 to 15 feet; Oroville, 5 to 6 feet.

From what has been said, it will be understood that these figures do not represent the full depth of filling in the beds of the rivers. It is difficult to determine just what this has been, for there were so few surveys made in early years with the results of which the present channel may be compared.

Filling in the River Channels.

From the surveys made under my direction, in which the river channels have been accurately aligned, measured, and cross-sectioned at many points, and, at some localities re-examined repeatedly during the year, together with a study of the profiles made by levelling work, and by the aid of information collected from various sources, I am enabled to make an estimate of the probable total amount of filling which has taken place in the channels of the main valley rivers, wherein the sands from the mining streams have had entrance, viz.: the Feather River channel, and that of the Sacramento below the mouth of Feather. The following table exhibits the result of these studies and estimates:

TABLE

Showing the results of estimates of amounts of sand lodged in the channels of the FEATHER AND SACRAMENTO RIVERS *from Oroville to New York Landing.*

RIVER.	Number of the division	Length of the channel, in miles	Average width between the banks, in feet	Area of the water surface of the channel, in square feet	Rise in plane of low water, in feet	Cubical contents of space between former and present low water surface, in cub. yds.	Probable average depth of filling of sands in the channels, in feet	Quantity of sands in the river beds, based upon the probable filling in the channel—cub. yds.	Locality.
Feather	I	12.8	200	13,516,800	5.0	2,503,111	10	5,006,222	Oroville to Burt's Ferry.
Feather	II	24.2	280	35,777,280	5.0	6,625,420	10	13,250,840	Burt's Ferry to Yuba River.
Feather	III	19.6	330	34,151,040	9.0	11,383,680	20	25,297,030	Yuba River to Nicolaus.
Feather	IV	10.4	340	18,670,080	3.5	2,420,095	10	6,914,841	Nicolaus to mouth of river.
Sacramento	V	19.74	517	53,885,460	4.5	8,980,910	15	29,936,225	Feather River to American River.
Sacramento	VI	27.7	531	77,661,936	3.5	10,067,284	10	28,756,272	American River to Grand Island.
Sacramento	VII	18.28	381	36,773,510	1.5	2,042,972	5	6,809,910	Old River channel.
		11.9	407	25,572,624	1.75	1,650,077	10	9,471,342	Steamboat Slough channel.
Sacramento	VIII	15.8	1,163	97,022,112	0.75	2,695,058		7,186,822	Principal filling on the Newtown and other shoals (approximate).
Sacramento	IX	2.87		64,062,500	0.0			1,186,342	Principal filling on the Collinsville Shoals (approximate).
Totals						48,368,607		133,869,846	

Sand deposits in the main river channels.

From the foregoing table it is seen that the space between the low water plane of the period anterior to the commencement of mining, and that of the low water stage of 1879, is 48,368,607 cubic yards in bulk in the Sacramento River and Feather River channels from Collinsville to Oroville.

As pointed out in a preceding paragraph, the rising of the plane of low water has been occasioned by the filling up of the river channel, but the extent of this apparent displacement of the water surface does not represent the full measure of change which may have and probably has taken place in the position of the bottom line, which latter movement is to be accepted, when determined, as the index to the extent of filling in the channel.

It is safe to say beyond all dispute, that the beds of these rivers have filled in to the extent of the movement of the low water surface, viz.: in bulk to the amount represented by the 48,368,607 cubic yards above mentioned.

Probable filling—Feather River channel.

Beyond this, we know that at certain places changes have taken place which would indicate that a very much greater bulk of matter had found its resting place in these channels.

For instance: *At Oroville* it is known that the Feather River channel has been filled at certain points where deep holes existed, as much as thirty to thirty-five feet in depth. Such deep holes alternated with shallow rapids, where the waters in low stages ran over rock ledges or heavy cobble stone bars. These deep holes and reaches were to be found all the way down the river, becoming less and less marked, to the mouth of Yuba. They no longer exist to any considerable extent.

At Burt's Ferry, 12.8 miles below Oroville, there formerly existed a channel six to fourteen feet in depth at low water, for a long reach of the river. All persons at all acquainted with this locality in former times, coincide in opinion on this point, so far as I have been able to learn. Now this reach is filled with sand until it is only two to four feet in depth at low water.

At the mouth of the Yuba River, from the mass of opinion and evidence on the subject, and from a study of the profile of the stream, I am inclined to believe that the Feather River channel has filled in, on an average, between banks, about eighteen feet in depth.

All along the Feather River below the Yuba, localities are pointed out where once long deep and wide reaches existed, but where now the river runs over a bed of sand, with low banks, and bars appearing on one side or the other.

At the mouth of the Feather River, all of the information to be had points to a considerable filling, and judging from conservative statements as to former condition of the channel and the low water plane, the sands have settled there for a distance of three miles, certainly, to an average depth of ten feet.

Probable filling—Sacramento River channel.

From the *Feather River to the American* the Sacramento shows unmistakable evidences of having filled greatly. Nothing definite has been learned however, but it is known that at localities where comparatively deep reaches formerly existed bars are now to be

found, and that although the plane of low water has raised several feet, as elsewhere spoken of, the old bars are now nearer the surface than ever, and navigation during low water is impeded, even when light draught boats are used, where formerly comparatively heavy draught boats ran without hindrance.

Furthermore, a study of the profile of the Sacramento River, whereon the bottom line of the channel is represented, above and below the mouth of Feather River, brings a strong sense of the fact that a very considerable filling has taken place in the main river below the point spoken of.

At and just below the mouth of the American River, we have the best evidence of this class of change in the channel.

In 1854, a survey was made by the City Surveyor, under the direction of the City Council of Sacramento, and soundings were taken in the river channel from a point just above where the mouth of the American River is now, along the city front to the lower end thereof—a distance of about two miles. These soundings were made at extreme low water of that year and reduced to a low tide plane (there being at that time about 18 to 22 inches of tidal effect noticeable), and platted on a map of scale 400 feet in one inch. A copy of this map is at hand, lithographed in 1855, with the sounding depths shown, and the reading of the gauge (reference of which has been kept and transferred to the present gauges) is known from good records, for the low water low tide phase of that year. The position of the bottom at that time is therefore known. During the low water of 1879 this ground was sounded over, and the work connected up with the old survey.

A comparison of results shows a maximum filling of thirty feet, and an average fill over the whole surface of about 15.2 feet.

Some data of local changes below Sacramento derived from accounts of those familiar with the river for years in the past, lead to the belief that such filling has taken place, to a somewhat less extent perhaps, at a number of points, as for instance, in the reach above the head of Grand Island, and again in the neighborhood of Clarksburg, and more noticeably in the Freeport reach, which was formerly remarkable for its depth, but now has two bars which are almost exposed at low water, and is comparatively shallow throughout.

In Steamboat Slough the channel of the river which bounds Grand Island on the north, the filling is more marked than elsewhere. Depths of twenty or thirty feet were formerly common where now six to twelve feet only is to be found at low water through this channel, and although in times past it was navigable throughout for large steamers drawing five and six feet, and of ample depth at all times of the year, except at the Hogsback bar, now it is scarcely passable at low water for craft drawing three or four feet, and shoals are found almost throughout the full length of its course.

In Old River channel, although the low water plane has raised, as shown, it has become shallower almost for its entire length, and some few reaches which were of good depth have shoaled in a more marked degree as in other cases.

Below Grand Island, the only considerable fillings which can be recognized are on the Newtown Shoals, just above Wood Island and Rio Vista, about the head of Three-mile Slough, and on the shoal opposite Collinsville. The only data upon which an estimate of the filling at these points, from very early times, may be based is that

derived from the statements of those who have regularly navigated the stream, and, to be on the safe side, a very small allowance has been made in the estimate for these changes.

Effects of the deposits—Navigation.

The fact that these rivers have become much less useful than they formerly were as channels of navigation has been referred to and some comparisons drawn in previous paragraphs hereof. I have no means of making any more definite statement than these already put forth concerning this point. The general assertion that in the portions of the rivers before spoken of more particularly, the navigation is now brought down to boats of much lighter draught than were formerly used, is but the recital of a well known and recognized fact; and that under present influences matters will become worse in this respect, there can be no doubt, though probably the rate of progression will not be so great as it has been in the past.

These remarks apply, of course, to the Feather River, but more particularly to the Sacramento, below the mouth of the Feather.

Above this point, on the Sacramento, it cannot be said that the navigation has been injured; indeed, if anything, it has been improved by the waters being held at a higher level for some distance without the channel having shoaled.

Effects of these deposits—Carrying capacity.

A study of this subject has led me to the conclusion that by the raising of their beds the Feather River and Sacramento River below the mouth of Feather, have been diminished in carrying capacity on an average about thirty per cent. of their former ability to pass flood waters between their natural banks, and that at points this capacity has been reduced as much as fifty per cent., so that could these rivers have been brought to one uniform capacity before the extraordinary filling commenced—that is, could the bars and bad bends have been taken out then (as they could have been at comparatively small expense by a proper treatment) the whole channel would have been of double the capacity it is to-day, and would have remained at that or become still greater if the flow of sands had not come.

MINING DETRITUS AND THE VALLEY LANDS.

The lands bordering the Feather, Yuba, and Bear Rivers, as well as those adjacent to a number of smaller streams of the Sacramento Valley, which have received the flow of debris or detritus, were for the most part naturally very fertile, as all moist alluvial bottoms are. Even before the era of hydraulic mining they were generally subject to occasional overflow, and some of them were liable to annual flooding. Prior to the filling of the immediate channels with detritus, however, the floods, rarely of long duration, receded rapidly, and effected no material damage to lands or crops. The lands were sometimes in a high state of cultivation, and were dotted with prosperous homes, fruitful orchards, and luxuriant fields. But a great change has been wrought in the landscape—one which it is not pleasant to contemplate. By the rapid accumulation of the sands the natural channels of the Yuba and Bear Rivers were first obliterated, and the beds of the streams raised to a level with the top of their former banks. Levees that were thrown up to confine the waters to their accustomed

courses only had the effect of causing the beds to rise still higher by the constant deposition of detritus between them, until they were finally overtopped by the floods, and the bottom lands were submerged from rim to rim of the adjacent plains with sand and clay sediment, to such depths that in places orchards, gardens, fields, and dwellings were buried from sight, landmarks were lost, and the course of the devastating flood was marked out by broad commons of slimes and sands. Over these the streams now spread at will in many shifting channels, checked only by the dense clumps of willows and other semi-aquatic growth that thrive on the submerged territory, and confined between levees now set long distances apart, generally on the ridges of highland that formerly marked the boundary of the more fertile bottoms.

The estimate of damage.

The areas of the lands thus submerged has been computed in the various localities, and the extent of the damage resulting has been approximately determined, all of which is presented in convenient form in a table at the close of this chapter. Referring to this table, let us now consider each section in detail. Besides, being itself an immediate receptacle for mining tailings, Feather River is the recipient of the drainage of several of the principal streams into which such materials are dumped. The lands adjacent to it are, therefore, directly or indirectly affected by the detritus which these streams bring to it at various points, as well as by the sands placed in its own channel. For convenience, the damage along the Feather River will be considered in several distinct sections.

Damages along Feather River.

Along Feather River above Marysville.

The debris brought into Feather River by the Yuba has built up a high bar at the mouth of the latter, elevating the low water plane of the Feather so greatly that its influence is felt for ten miles above. The adjacent lands are thus more easily overflowed, and although not buried with detritus, are rendered marshy, cold, and unsusceptible of cultivation. To say that they are "drowned out" expresses their condition precisely. Some 1,500 acres have been thus affected. When these lands were examined early in May, 1879, by an Assistant Engineer of this Department, in a reconnoissance extending from Marysville to Burt's Ferry, water was found to have stood for two months previously on orchards and fields which, prior to the gorging of the rivers with detritus, had never been submerged more than two or three days at a time. Even the great flood of 1862 did not subject them to a longer overflow. Tracts that formerly rented at $50 per acre per annum cannot now be rented at $5; this depreciation being caused by the impossibility of raising crops on lands subjected to such prolonged flooding. In May last, lands that had formerly been planted during March in corn and potatoes, were six to eight feet under water. The former value of these lands was about $100 an acre, while they are now considered worth but $10 an acre, a value which may be said to be rather prospective than actual —depending on future possibilities rather than present reality. On this tract of 1,500 acres the loss to the owners in depreciation alone can thus be estimated at $135,000. The owners are, moreover,

not the sole losers by the depreciation in value, for had the lands maintained their former value a much greater revenue would have been derived from them by the State as well as by the county. If we take the rate of the State tax for 1879 (55 cents per $100) as a criterion, and presume the land to be assessed at one-half its depreciated value, it is apparent that the State has suffered an annual loss of $371 25 on this tract since it was damaged. This tax of 55 cents per $100 is next to the lowest State tax ever collected. In the further estimates that have been made in the table referred to, it has been used in preference to any higher rate, in order that our figures shall not exceed reasonable limits. The same cause which has damaged this " drowned out " tract, has on the contrary bestowed a benefit on adjacent lands higher up, rendering them cultivable and productive by a power of sub-irrigation, where they had before been too dry. That they, too, may be submerged by backwater is only a question of time, however, unless the forces at work be be effectually counteracted.

Along Feather River—Yuba City to Shanghae Bend.

On the right bank of Feather River, immediately below the mouth of the Yuba, some 700 acres have been covered, to a greater or less extent, with deposits of the Yuba River debris; and, by the rising of the bed of the Feather, rendered more than ordinarily subject to disastrous floods. This land was formerly quite valuable, and is, or has been, planted principally in orchards and small fruits. Prior to the erection of levees, which surround the tract, ten thousand fruit trees were killed by floods. These outer levees have been overtopped by high water and practically destroyed, ten thousand additional trees have been ruined, and the land damaged to such an extent that they are about abandoned. The loss in crops and damage to works, etc., have doubtless been several times greater than the loss in depreciation of land value, which has been reduced from $100 to less than $10 an acre, amounting in the aggregate to $63,000. The annual loss to the State, in taxes on this tract, may be safely estimated at $173 25.

Feather River, right bank—Shanghae Bend to Starr's Landing.

From Shanghae Bend to Starr's Landing, on the right bank, 1,200 acres have been more or less damaged. The land was formerly somewhat cut up by sloughs, but was quite valuable on account of its fertility. Its former price averaged about $60 per acre, but in its present condition $5 per acre would be considered enough for the seller, a depreciation which represents a loss in the aggregate to the owners of about $66,000, and an annual loss to the State, in taxes, of $181 50.

Feather River, right bank—Starr's Landing to Fremont.

In a distance of 19 miles, from Starr's Landing to Fremont, a narrow belt of land, aggregating some 6,700 acres in area, has been damaged from the same cause—by deposits of debris over the surface, and by floods that proceed from the raised and gorged condition of the river channel. The struggle against the encroachments of the flood-waters, which yearly rise to greater heights, has involved the farmers in heavy expenditure. Levee District No. 5, a portion of which lies along this section of the river, has been temporarily abandoned, after the expenditures of upwards of $100,000 along this frontage; and in other districts the yearly tax for maintaining the fight

is very high. The richness and fertility of the soil where protected from overflow is, however, in some cases such as to justify an extravagant outlay for the protection of the crops which can be produced. To the extent above named—7,600 acres—from a value formerly estimated at $20 an acre, the lands have depreciated to $2 per acre, representing a loss to the owners of $120,600, and to the State, in annual taxes, $331 65.

Along Feather, left bank—Marysville to Shanghae Bend.

On the left or eastern bank of Feather River, the damage has not yet been so widespread. The burden of warding it off has fallen heavily upon the land owners of Levee District No. 2, whose works partly protect a much greater area than is embraced within its limits. Between the Yuba Bridge at Marysville and Shanghae Bend, a distance of 2¼ miles, we find an aggregate area of 1,470 acres burdened with its unwelcome blanket of debris, which has reduced its marketable value from $100 to 50 cents per acre. By this estimate the owners have suffered a loss by depreciation in value of land of $146,265, and the State loses $402 22 annually in taxes.

Feather River, left bank—Shanghae Bend to Reed's Creek.

Although the detritus has been deposited in some places to a depth of several feet along this section of the river, it is generally thinly spread, and the lands have suffered less from the deposition than from the "drowning out" process, to which it is regularly subjected by the protracted floods. The area thus damaged is estimated at 3,396 acres, whose former value was $25 per acre. It is not considered worth more than $10 per acre at present; so that we find here an aggregate depreciation of $50,940, and an annual loss to the State, in taxes, of $140 08.

Feather River, left bank—Reed's Creek to Nicolaus.

The damage along this section of the river has been chiefly confined to the lands lying just above the mouth of Bear River and outside the levees of District No. 2. Above Bear River there are 4,600 acres which can now be bought for $1 75, but were once valued at $50 per acre. They are not all covered by sediments to any considerable depth, but are subject to protracted annual overflow, resulting from the same causes heretofore referred to. Portions of these lands are reclaimable, but the owners have become so embarrassed by repeated losses of crops and levees from floods, as to be unable to build levees capable of withstanding ordinary freshets. Of all the lands damaged it is estimated that about 2,080 acres have been directly covered with the detritus, reducing their value from $40 to about $4 per acre—a depreciation of $74,880 to the owners, by which the State loses annually in taxes the sum of $205 92. The total depreciation, caused by *overflow* has not been included in the estimate. Indeed, it would scarcely be possible, with any considerable degree of accuracy, to calculate the damage indirectly resulting from this cause, and doubtless it would be unjust to attribute the losses wholly to the effects of mining detritus. The low lands bordering the river have always been subject to inundation, and, although the deposits in the channel have increased, the difficulties of preventing the encroachments of the river waters upon the lands to some extent were great in all parts;

so that it is questionable if the levee system was ever sufficiently perfect to have avoided these dangers, even without any such deposition in the bed of the main stream. Where damages from "drowning out" have been included in this estimate, they are considered directly attributable to the effects of sands from the cañons of the mining regions, as in the case of the lands along the Feather above the mouth of the Yuba, where the latter stream has deposited a permanent partial dam across the Feather to a height of 15 or 16 feet. This dam the Feather River has been incapable of removing, and its waters have thus been impounded at a height so much higher than its original stage as to cause the "drowning out" of the adjacent lands above.

Recapitulation of damages along Feather River.

Summarizing the estimate of damages to lands along both banks of the Feather, for forty miles of its course more directly traceable to the sand and sediment from the mining dumps, we see that the owners of 17,046 acres have suffered a loss of $656,685, while the State loses in taxes $1,805 87 annually. The losses to the individuals in the destruction of crops, fences, and other improvements, as well as that suffered by the counties in the matter of taxes, is not capable of definite estimation, but is probably several times the amount of the more tangible loss in value of lands.

Damages along the Yuba River.

Yuba cañon to third standard north.

From a point which may be taken as the former mouth of the cañon of Yuba River to the third standard parallel north—the north line of township tier 15 north, a distance of six miles, about 6,500 acres have been covered with sand, gravel, and fine sediment. From $40 to 50 cents per acre represents the extent of the depreciation in value, amounting altogether to $256,750, and as the result of this the State loses annually in taxes $706 06.

From third standard to Marysville.

Below the third standard to Yuba bridge, at Marysville, some 7,600 acres of land that was formerly a rich alluvial bottom, dotted with fine orchards and gardens, have been burried in debris. One tract of about 640 acres, upon which a particularly valuable orchard was once growing, was considered worth $240,000. But a few of the tree tops are now to be found protruding above the sand with which they have been covered. The average valuation of these lands before the damage took place, is estimated at about $100 per acre, while some tracts were held at $300 an acre. To estimate the present value at 50 cents per acre would be sufficiently liberal, and shows a depreciation of $756,200. The State loses $2,079 55 annually in the matter of taxes.

In the vicinity of Marysville.

The Brown's Valley grade, which extends northeastward from Marysville, parallel with the valley of the Yuba, has been broken in several places, and the detritus has spread over land lying between this levee and Feather River, back of the city, covering some 1,120 acres, depreciating their value from $75 to about $20 per acre, amounting in the aggregate to $61,600. The State loses annually $169 40 in taxes.

Recapitulation of losses on the Yuba.

The total area thus damaged by detritus on the Yuba River foots up 15,220 acres, which have suffered a depreciation in value of $1,074,550; and the annual State taxes have been thereby reduced $2,955.

Depreciation in value of real estate in Marysville.

The measure of damage to the City of Marysville by the encroachment of the sands cannot be estimated by the annual cost of repairing and maintaining levees, or by the steady depreciation in value of real estate. It is a matter of interest, however, to observe how this depreciation has progressed from time to time, while other more fortunate cities of California have been advancing in wealth, population and prosperity. The appended table, furnished by Mr. H. C. Newberry, Assessor, gives the assessed valuation of this property for each fifth year since 1855:

Year.	Value of land.	Value of improvements.	Value of personal property.	Total valuation.
1855	$1,392,303	$801,580	$1,160,210	$3,354,091
1860	972,094	1,030,125	1,821,299	3,823,518
1865	389,317	812,670	1,148,692	2,350,679
1870	257,580	713,320	873,440	1,844,340
1875	517,670	787,690	801,465	2,106,825
1880	365,575	718,180	620,145	1,703,900

To what extent this decadence is attributable to the influence of detritus cannot be estimated, for other causes may have been at work to produce stagnation of business and decrease in population, in which case the special effect of each I am not in a position to estimate. But when we consider the danger in which the property now is of further great harm, and the inconveniences suffered by the residents in many ways, as a consequence of this rising of the adjacent channels and waters, the heavy taxes imposed upon them for the construction and maintenance of levees, etc., it is not to be wondered that property values should be depreciated and business depressed.

Damages along Bear River.

The damage from detritus along Bear River, while not so extensive as on the Yuba, has been none the less complete. From the cañon of the river to the overflow line from Feather River, a distance of twelve miles, the area covered with debris is about 8,800 acres, of which 6,400 acres is above the railroad bridge, and 2,400 acres below. Much of this land was quite as fertile, valuable, and highly improved as that of the Yuba bottoms, but it has no greater present value than about 50 cents per acre. The total depreciation is estimated at $779,600, representing a loss to the State, in taxes, of $2,143 90 annually.

Along Auburn Ravine and Roseville Creeks.

The aggregate area of sediment-covered lands along these streams is about 2,480 acres. The former value was about $40 per acre; at present these lands are valued at about $5 per acre. The depreciation is $86,800. There are other lands, and to a greater area in this region, which are injured by the raising of the waters in the main rivers cutting off their drainage.

Summary of Land Damage.

Reviewing the losses which are capable of estimation, we find an aggregate area of 43,546 acres which have suffered a depreciation in value of $2,597,635. The loss to the State, in taxes, upon the basis explained, amounts to $7,143 48 annually. Some additions to this will afterwards be noticed; but these, because less definitely ascertained, are not to be ranked, and could not be tabled with the foregoing.

TABLE

Showing depreciation in value of lands damaged by mining debris.

Locality.	Area, in acres.	Probable present value, if not covered with debris.		Present value.		Depreciation to owners.	Yearly loss to State, in taxes.
		Per acre.	Total.	Per acre.	Total.		
On right and left bank of Feather River, above Marysville, "drowned out" from rise in low water elevation	1,500	$100	$150,000	$10 00	$15,000	$135,000	$371 25
Right bank of Feather River, from Yuba City to Shanghae Bend	700	100	70,000	10 00	7,000	63,000	173 25
From Shanghae Bend to Starr's Landing	1,200	60	72,000	5 00	6,000	66,000	181 50
Starr's Landing to Fremont	6,700	20	134,000	2 00	13,400	120,600	331 65
North of Marysville, east of Feather, west of Brown's Valley Grade	1,120	75	84,000	20 00	22,400	61,600	169 40
Left bank of Feather River, from the mouth of Yuba River, down to Shanghae Bend	1,470	100	147,000	50	735	146,265	402 22
Left Bank of Feather River, from Shanghae Bend to Reed's Creek	3,396	25	84,900	10 00	33,960	50,940	140 08
From Reed's Creek to Nicolaus	2,080	40	83,200	4 00	8,320	74,880	205 92
Between County Bridge, at Marysville, and third standard parallel north	7,600	100	760,000	50	3,800	756,200	2,079 55
From third standard to Yuba Cañon foothills	6,500	40	260,000	50	3,250	256,750	706 06
Bear River Bottoms, from the mouth of Bear River to the Railroad Bridge	6,400	100	640,000	50	3,200	636,800	1,751 20
Bear River Bottoms, from the Railroad Bridge to the mouth of the cañon	2,400	60	144,000	50	1,200	142,800	392 70
Lands covered and "drowned out" on Auburn Ravine, Roseville, and Dry Creek	2,480	40	99,200	5 00	12,400	86,800	238 70
Totals	43,546		$2,728,300		$130,665	$2,597,635	$7,143 48

Sediments from Table Mountain Creek.

In addition to the lands along the Feather River and its tributaries affected by the flow of sands and sediment from the mining tailings, a large area of country has been covered with a similar material, or subjected to overflow of waters from like causes, in Butte County, along what is known as Table Mountain Dry Creek, and lower down on Butte Creek, and in the sink or basin thereof.

This overflow has resulted in damage in some instances and in benefit in others; and the mining company whose works have caused the greater portion of these changes has gone to great expense in endeavoring to prevent the spread of silt-laden waters by the construction of a canal for their guidance, and with considerable success. Furthermore, this company has bought up large tracts of land subject to overflow from their workings, so that it is impossible for me to say what has been the extent of the injury done in this neighborhood. Indeed, it is claimed that by a proper management of this matter the farming lands could be greatly benefited by a deposit of the material brought down upon them; and there is some evidence to show that on certain of the soils such would be the result. But at the same time that much injury has been done under other circumstances from this same cause and in this neighborhood there can be no doubt.

The total area covered by sediments from this source is about 12,900 acres, but the deposit is generally very thin, not over a foot in depth, and the greater portion is more damaged for present purposes by water spreading and standing upon the ground than by the deposition of solid material thereon. Lands to the extent of several thousands of acres which were formerly valuable as stock range, and held at five to ten dollars per acre for that purpose, are now of but little use, for the muddy waters stand upon them the year round. This is in what has been heretofore spoken of as the Butte Basin, and it is caused by the stoppage of the channels of escape by sediment and the continued flow of water where once the supply ceased altogether in the early spring.

Conclusions.

In closing this part of the present subject, it is but right to call attention to the fact that the estimates heretofore made with respect to property depreciation are based altogether upon hearsay evidence. I have endeavored myself, and through the work of my assistants, to arrive at a just estimate, and I believe the statements made, as far as they go, are moderate and to be relied upon as far as could be expected in the absence of a thorough inquiry in detail which I have not been able to make.

At the same time there are benefits to some lands to be observed from the deposit of sediments upon them and from the rising of adjacent waters making them moist and cultivable; but I have not had the time to look far enough into this matter to estimate the extent of such changes.

NOTE.—In the foregoing chapter where it has been said that certain sums have been lost to the State by reason of depreciation in land values, it should be understood that these sums were paid, of course, by other property in the State, and that the State has really not suffered the loss directly, but indirectly through a depreciation of taxable values.

CHAPTER II.

REMEDIES FOR THE EFFECTS OF THE FLOW OF SANDS, AND PREVENTIVES OF FUTURE DAMAGE.

EXTENT OF HYDRAULIC MINING.

I have endeavored to obtain some definite knowledge of the extent of the flow of sands and sediments from the mining streams into the Sacramento Valley. The study is not complete. A great variation is observable in the effect of the use of water at different localities, and it takes time to watch the progress of work after the first observations are made, before any result can be obtained which will be wholly reliable. Furthermore, I have not been able to collect full statistics of the use of water—the amount used—and have been obliged to supplement the exact but partial data at hand, with estimates based on less reliable and full statements.

The mining duty of water.

The measure of water used in mining is expressed in different localities by the common term, the *miners' inch.* But this quantity varies greatly; in some places being as low as 2,000, and in others as high as 2,600 cubic feet in 24 hours, so that the duty—the amount of material washed out—must also vary. Besides, this is greatly affected by the circumstances under which it is used; as for instance, the character of the material washed, the volume of water used, the pressure under which it is applied, and the grade of the sluices in which it is carried away. Thus, I have found that in the deep washings at Dutch Flat, where heavy bowlders and cobbles constitute a large part of the material moved, water used in large volume under very heavy pressure, and with tailing sluices of heavy grade to carry away the material, has only accomplished a duty of removing 1.4 to 2 cubic yards per 24-hour inch of about the medium volume; while at other localities as high as 6 cubic yards are removed by the same quantity of water, and under no more favorable circumstances—the variation being solely due to the difference in the character of the material washed out.

The materials washed.

In the Polar Star and Southern Cross mines at Dutch Flat—two of the deep washings spoken of—I have estimated that nearly fifty per cent. of the material moved is of a character which need never be carried a mile below the dumps; it is of heavy rock and cobble stones, and probably not over forty-five per cent. of the whole need ever become sandy and sedimentary in character, if reservoired before being transported very far; so that all but about fifteen per

cent. could be readily held behind dams and other obstructions in the cañons. On the other hand, in some washings, and deep ones too, the tailings are fully three-fourths sand and fine sediments, and the remainder nearly all of partly decomposed rocks or gravel, which soon grind down to forms of extreme fineness.

Actual duty of water.

From such examinations as I have been able to make, I am inclined to believe that the 24-hour inch of water used, accomplishes duties about as follows: On the Yuba River, 3½ cubic yards; on the Bear River, 3 cubic yards; on the American River, 4½ cubic yards. These, of course, are figures for the average of all the mines in each of the river basins mentioned, and are based on very good data. I have no information from which to judge of the duty in other quarters, except that it must be considerably smaller on the Auburn Ravine and Roseville Creeks, for water is there used in small volumes only, on low banks, with tailing sluices of rather light grades, and materials not particularly easy to move. I have, therefore, assessed a duty of 2 cubic yards for these localities. For the Feather and Butte Creek washings I have taken the average found elsewhere, namely, 3½ cubic yards. This is a high figure for the lower Feather washings—those near Oroville—but probably it is low for the higher works in Plumas County, so the result will be about right.

Water used and Material washed out per Annum.

The following table shows the results of the inquiry, so far as prosecuted, into the extent of hydraulic mining within the Sacramento basin:

Name of Stream.	Water used, in miners' inches of 24 hours.	Duty per inch, in cub. yards.	Material washed, in cubic yards.
Table Mountain Creek	1,016,000	3½	3,556,000
Feather River	3,625,000	3½	12,687,500
Yuba River	6,379,000	3½	22,326,500
Bear River	1,850,000	3	5,550,000
Auburn Ravine Roseville Creeks	340,000	2	680,000
American River	1,912,000	4½	8,604,000
	15,122,000		53,404,000

Thus it is seen that there are 15,122,000 miners' 24-hour inches of water used in hydraulic mining per annum upon the streams which drain into the Sacramento Valley, and 53,404,000 cubic yards of material of all grades are washed out by its use. This is rather an under estimate, it is believed, as to amount of water used, but some of the materials which are actually washed out do not reach the main cañons, thus making an offset in amount of sediment to be accounted for. This estimate does not include mining on the upper Sacramento River; for from this no bad results are noticeable, so far as known, in the valley.

Sediment carried in Suspension.

In Appendix B, to this part of the report, will be found an account of the sediment observations made under my direction, and I respectfully ask attention to that paper for an explanation of all matters of detail connected with this subject. I herewith present two tables showing the amount of sedimentary matter carried in suspension by the waters of such streams as have been observed in this valley, and similar data of other river waters are embodied in the same forms for convenience of comparison.

The waters of Table Mountain Creek are drained into the Butte basin, and thence into the Sutter basin, so that they, doubtless, are well clarified before reaching the river. This may be said also of those of the Auburn Ravine and Roseville Creeks, which spread into the American basin. Thus, it is only the waters of Feather, Yuba, Bear, and American, and those of the upper Sacramento itself which bring sediment in suspension to the main stream—that is, the river below Sacramento City.

Table of average volumes and weights.

Of the tabular exhibits which follow, Table No. 1 purports to show the volumes and weights of sediments in the waters of various rivers, as compared to the volumes and weights of the waters themselves. These results have been assumed by those who have determined them as representing the average quantities by weight and volume of the solid matter transported by the waters.

At the head of the list are the results of nine sets of averages for California river waters. The two first, by Mr. Geo. F. Allardt, C. E., and the others by Mr. M. Manson, C. E., who has conducted the work, under my direction, for this department.

Maximum and average determinations.

Mr. Allardt's results are from a few determinations from samples taken during low stage of Bear River, when its waters are most heavily charged with suspended matter, and these figures should be taken rather as showing the heaviest amount of material found in suspension than the average amount carried by the waters, and hence should probably be in Table No. 2, where it is found they would agree well with results obtained by Mr. Manson from the waters of the same river when most heavily charged, during the low water periods.

Specific gravity and reductions made.

In explanation of results obtained by this department it is only necessary to remark here that the determinations were made by the filtering process, and the sediments subsequently dried and weighed. The actual specific gravity of these sediments, as they exist in powdery form in the water, is about 1.9, but the specific gravity of the material as naturally deposited from the water has been determined at about 1.4; and seeing that it is as thus deposited we have to deal with them, the latter result is taken as the ratio between the weight and volume, and by its use the reductions to bulk from weight have been made in compiling these tables.

Compared to the magnitude of this subject, the number of deter-

minations is small from which to calculate final results, and it is by no means claimed that this particular work of ascertaining the amount of material carried out in suspension by the waters has been exhaustive, or that there may not be material error in it, resulting from the limited time and means at hand for its accomplishment. In my opinion, however, a fair approximation to the truth has been arrived at.

The work of making these analytical determinations was performed by M. Manson, Assistant Engineer, in the laboratory of the State University, at Berkeley. It gives me pleasure to acknowledge the obligations under which this Department has been placed by Drs. John and Joseph Le Conte, Professors Hilgard and Rising, and their assistants, whose unvarying courtesy and kindness greatly promoted the progress and success of the work.

Table of maximum volumes and weights.

Table No. 2 purports to show the same data as the preceding table, only that the instances taken are extreme cases—or, in other words, only results are given for the determination whereby the greatest quantities of sediment were found in the waters.

TABLE No. 1.

Showing the volumes and weights of sediments in the waters of various rivers.

Name of River.	Locality.	Date.	Proportion of sediment to water. Pounds in 1,000,000	Proportion of sediment to water. Cub. ft. in 1,000,000	Authority.	Remarks.
California Rivers.						
Bear	Opposite Auburn	1878	40000	28570	G. F. Allardt	July, 1878. Testimony in Keyes vs. Little York M'g Co. et al.
Bear	At Railroad Bridge	1878		37500		July 27, '78. Testimony in Keyes vs. Little York M'g Co. et al.
Bear	Wheat'd to Wire Br'ge	1879	16320	11660	M. Manson	Mean 21 determinations throughout the year. } State Eng'r Department, W. H. Hall, State Engineer.
Yuba	Marysville	1879	6290	4490	M. Manson	Mean 41 determinations throughout the year.
Feather	Burt's Ferry	1879	358	556	M. Manson	Mean 11 determinations, low and high water.
Feather	Near its mouth	1879	1322	944	M. Manson	Mean 16 determinations, low and high water.
American	Near its mouth	1879	4598	3274	M. Manson	Mean 9 determinations, low and high water.
Sacramento	Above Feather	1879	78	54	M. Manson	Mean 7 determinations, low and high water.
Sacramento	Below the American	1879	1001	715	M. Manson	Mean 35 determinations, high water and flood.
Foreign Rivers.						
Rhone	Lyons, France	1844	59		M. Surrell	For 4 months. } Humphreys & Abbot's Report on Mississippi Delta Survey—1876.
Rhone	Arles, France	1808–9	500		Gorsse and Subour	
Rhone	Delta		400		M. Surell	
Po				3333	M. Tadini	
Danube				416	Spratt	Summer Floods—Beardmore.
Garonne			190	130	Mr. Baumgarten	Hydraulic Manual and Statistics—Jackson.
Durance	Marseilles Canal		4250	2120	Director of Canal	Traité D'Hydraulique—Duponchel.
	Sewers of Paris		1680			Mean for 3 years—1867–'68–'69—Assainissement de la Seine.
Indus	Kotree series		1490			
Indus	Sukkur		1940			
Indus	Sukkur, flood series		4220			Mean result of 29 observations, from July 23d to Aug. 9th.
Nile			1580		Mr. Horner	Hydraulic Manual and Statistics—Jackson.
Yellow			3330		Sir G. Staunton	Hydraulic Manual and Statistics—Jackson.
Ganges			1961	980	Mr. Everest	For 12 months—Humphreys & Abbot's Report.
Hoogly	Calcutta		680		Dr. Macnamara	Hydraulic Manual and Statistics—Jackson.
Irrawaddy			580	305	Mr. Login	Hydraulic Manual and Statistics—Jackson.

TABLE No. 1.—Continued.

NAME OF RIVER.	Locality.	Date.	Proportion of sediment to water. Pounds in 1,000,000	Proportion of sediment to water. Cub. ft. in 1,000,000	Authority.	Remarks.
Rhone	Bonn		60	32	Mr. Horner	Hydraulic Manual and Statistics—Jackson.
Seine	Rouen		20	11	M. Marchal	Hydraulic Manual and Statistics—Jackson.
Danube			57	30	M. Marchal	Hydraulic Manual and Statistics—Jackson.
Nile		1874	532		Dr. Letheby	July to Oct. Hydraulic Manual and Statistics—Jackson.
Mississippi	Carrollton, Missouri	1851–2	553	291	Professor Forshey	For 12 months.
Mississippi	Carrollton, Missouri	1852–3	690	363	Professor Forshey	For 12 months.
Mississippi	Columbus, Mississippi	1858	726	398	Webster & Filiebrown	For 9 months.
Mississippi	The mouths	1838	796	419	Mr. Meade	For 2 months.
Mississippi	The mouths	1838	580	305	Mr. Sidell	Humphreys & Abbot's Report on Mississippi Delta Surveys, 1876.
Mississippi	Various points	1843	803	422	Professor Riddell	For 14 days, summer of 1843.
Mississippi	New Orleans	1843	865	333	Professor Riddell	For 35 days, summer of 1843.
Mississippi	Natchez	1846–8		1893	Mr. Brown	Irregular dates, 1846–'48.
Mississippi	Memphis	1849	1677	882	Lieutenant Marr	3.5 flood months.
Mississippi	Memphis	1850–1		342	Lieutenant Marr	

NOTE.—The volumes of sediment shown in these tables (obtained by dividing its weight by its specific gravity), when those of California are compared with foreign rivers, show an apparent discrepancy which requires explanation. The specific gravity of sediment found in California rivers was taken at 1.4 (the average of several determinations), which therefore became the divisor to obtain the volume. This figure represents the specific gravity of the sediment as it is naturally deposited upon lands, and about in the form it is to be dealt with in engineering operations. Other authorities quoted in these tables, however, having obtained the absolute specific gravity (which is about 1.9), have used that figure as the divisor of weight to obtain volume. To reach that specific gravity the material would be compressed into its smallest possible form, and more nearly approach stone than earth. For these reasons, therefore, the volume of sediment shown to exist in California rivers appears so much greater proportionally to its weight than that of other streams. The comparisons drawn between Californian and other rivers should thus be made by the weights, and not the relative volumes of sediment. The absolute specific gravity of California sedimentary deposits, when determined by their displacement of water, is about the same as that transported by the Mississippi, Ganges, Indus, and other silt-laden rivers.

TABLE No. 2.

Showing the heaviest amounts of suspended material found in various rivers.

Name of River.	Locality.	Date.	Proportion of sediment to water. Pounds in 1,000,000	Cub. ft. in 1,000,000	Authority.	Remarks.
California Rivers.						
Bear	Wire Bridge	1879	35640	25460	M. Manson	Sept. 6th, low water; mean of river. } State Engineer Department of California, W. H. Hall, State Engineer.
Bear	Wheatland	1879	31620	22590	M. Manson	Sept. 6th, low water; mean of river.
South Yuba	Bridgeport	1879	33680	24060	M. Manson	Oct. 22d, low water; mean of river.
Yuba	Marysville	1878	17890	12540	M. Manson	Dec. 5th, low water; mean of river.
Feather	Burt's Ferry	1879	560	400	M. Manson	Feb. 19th, medium flood; mean of river.
Feather	Near mouth	1879	1880	1280	M. Manson	May 13th, full stage; mean of river.
American	Near mouth	1879	15290	12350	M. Manson	Jan. 24th, medium flood; mean of river.
Sacramento	Above Feather	1879	124	88	M. Manson	May 12th, full stage; mean of river.
Sacramento	Freeport	1879	1320	940	M. Manson	March 3d, full stage; mean of river.
Sacramento	Sacramento	1879	1127	797	M. Manson	May 22d, full stage; mean of river.
Foreign Rivers.						
Indus	Sukkur, India	1856	3610		H. B. Medlicott	} Roorkee Papers; Indus silt experiments.
Indus	Kotree		1810			
Indus	Sukkur (flood series)		4950	2100	H. B. Medlicott	August 1st
Indus			4760		Col. Tremenheere, R. E.	Hydraulic Manual and Statistics—Jackson.
Ganges River	Hurdwar	1856	23100			August 2d } Roorkee Professional Papers.
Ganges Canal	Roorkee	1856	26100			August 2d
Nile		1874	1490		Mr. Fowler	Hydraulic Manual and Statistics—Jackson.
Nile		1874	1492		Dr. Letheby	August 12th, Hydraulic Manual and Statistics—Jackson.
Irrawaddy			580		Mr. Login	Hydraulic Manual and Statistics—Jackson.
Rhone	Arles		4350		M. Subour	Hydraulic Manual and Statistics—Jackson.
Rhone	Bonn		80		Mr. Horner	Hydraulic Manual and Statistics—Jackson.
Hoogly	Calcutta		1380		Dr. Macnamara	Hydraulic Manual and Statistics—Jackson.
Garonne			750		Mr. Baumgarten	Hydraulic Manual and Statistics—Jackson.
Mississippi	Columbus	1851	1492	774	Webster & Fillebrown	Third week in July } Humphreys & Abbot's Report on Mississippi Delta Survey.
Mississippi	Carrollton	1851	1468	772	Professor Forshey	Third week in June
Mississippi	Head of South Pass	1877	1231	648	Capt. M. R. Brown	August 2d.
Mississippi	Head of South Pass	1878	1694	892	Capt. M. R. Brown	June 29th.
Mississippi	Head of South Pass	1879	1586	835	Capt. M. R. Brown	February 1st.

Observations on the Tables.

An examination of these tables show that, so far as known, no stream of which there is record carries nearly so much sediment in suspension in proportion to their volumes as do the larger mining torrents of California—the Yuba and the Bear Rivers, in their low stages—and the Auburn Ravine, Roseville Creek, Butte Creek, and some other streams in this valley are about upon the same footing, although the results are not given herein. We find the Bear and Yuba waters carrying, during the autumn of the year, when their volumes are small, 3 to 3½ per cent. of sediment by weight, while the waters of the Ganges, the only river which approaches them at all in amount of material held in suspension, carry only about 2½ per cent., and the Durance—the famous muddy river of southern France—has but about four-tenths of one per cent. of sediment in its waters by weight, or a little over two-tenths of one per cent. by volume. In this connection it should be borne in mind that the above comparison is that of small rivers with a very large one, and therefore it is not altogether a fair statement; but I have no data for other comparisons. The Feather River carries twice as much sediment in suspension, in proportion to volume of discharge, as the Mississippi, and the Sacramento, below the American, one and one-half times as much as that river.

These comparisons of the Sacramento and Feather with the Mississippi are not altogether just either, for of course they are insignificant as compared with it in volume, and the general rule is that the smaller streams are found with the most sediment in their waters.

If we compare the Sacramento with the Indus, Nile, Yellow, and Ganges, rivers more nearly of its size, but still larger by far, we find that its waters carry less sediment in suspension than do theirs.

The American River waters, with a little less than one-half of one per cent. of sediment by weight in them, are on a par with the Indus and the Durance, the two muddiest rivers in the world (except the Ganges), of whose waters any statistics have been heretofore published to my knowledge. The Sacramento, above Feather River, is seen to be among the clearest of sediment-bearing rivers—having only about one-eighth as much sediment as the Mississippi, one-fifth as much as the upper Feather, one-eighteenth as much as the lower Feather, one-sixtieth as much as the American, one-eightieth as much as the Yuba, and one two-hundredth as much as the Bear River.

Origin of river silts.

The large muddy rivers of the world frequently derive their sediments from glacial action—the grinding of the ice over the material beneath it sends down torrents of water very highly charged with sediment so fine that it remains in suspension for a long time. The freezing and thawing, also, which takes place upon the mountain watersheds of such rivers, disintegrates the soils and rocks so as to make them wash away readily. The falling of avalanches, too, brings masses of material to where it is acted upon and carried away by the torrents. The Po, Adour, and some other rivers of Italy are thus chiefly supplied with the sediments their waters carry, though it is said that the destruction of forests has of late years greatly facilitated the washing down of the soils of their mountain basins by pluvial action unaided by other agencies.

The Ganges, Indus, and Yellow Rivers, heading in the Himalaya Mountains, derive their silt from the action of ice principally, while the Mississippi and the Nile receive theirs by the wash from mountains and hills, occasioned, for the most part, solely by rain waters. In some instances this action of the rains is notably aided by the destruction of forests, as on some of the watersheds of France where the whole country has been rendered perfectly barren since the trees were removed and the soil exposed to the full force of drainage waters. Comparatively small streams having rolling-land watersheds in settled farming localities derive much silt from field washings, but this does not account for silt brought out from mountain watersheds. It may be well understood, then, how the waters of smaller streams may be much more highly charged with silt than those of large rivers, for the result is often occasioned by purely local action, and while one tributary of a great stream may be very muddy, a number of others will probably be quite clear.

The river silts of California.

The creeks which enter San Francisco and Suisun Bays from the farms around are very heavily charged with silt after heavy rains, and particularly the first ones of winter. So also on the creeks which flow into the Colusa and Yolo basins in the Sacramento Valley. Doubtless a greater portion of these sediments are washed off from plowed lands. But there is no area of plowed ground on the Yuba or Bear Rivers sufficiently great for the washings therefrom to have any great effect upon the waters of those streams. On the American River watershed the wash from farming lands is much greater, judging from the area of country cultivated.

It may be that the washings from plowed lands and natural washings from the highlands of all sorts supply as much material towards the filling up of the Bay of San Francisco as do the sediments from the mines. I have no data sufficient to demonstrate this matter to the contrary, seeing that I do not know even approximately how much material is brought down by the streams outside of the Sacramento Valley. But of the causes which are acting upon the plains and river channels of the Sacramento Valley there can be no question but that mining operations are far the most potent, and are supplying the great mass of the material which is producing the changes herein spoken of.

Deductions from the Tables.

From the detail of results upon which these tables are based, and from a knowledge of the volumes of discharge of the various rivers, I am enabled to estimate approximately upon the amount of material in bulk brought down by the various large streams of the valley. The results of this estimate for the past year ending in the fall of 1879, are as follows:

AMOUNT OF MATERIAL TRANSPORTED BY THE RIVER WATERS.

Upper Sacramento River	2,100,000 cubic yards.
Feather River	11,500,000 cubic yards.
American River	4,500,000 cubic yards.
Lower Sacramento River	16,000,000 cubic yards.

The sum of the first three should equal the last one, if no water escaped; but, as it is, the difference—2,100,000 cubic yards—represents

the quantity deposited in the Sutter, American, and Yolo basins, or escaping through the latter at extreme flood stages. It is, of course, to be understood that these quantities apply only to the material carried up in the water in suspension, and not to the sands rolled along the bottoms of the channel way.

Natural and mining sediments.

Taking the volume of material carried by the upper Sacramento as a guide, I am enabled to judge somewhat of the amount washed off from lands by natural action. Then, with drainage areas considered, and a liberal allowance for wash from old mining dumps and deposits, and from heavily cut roads, etc., I am enabled, in the case of the Feather and the American, to estimate upon the portion of their sediments in suspension due to similar causes—the natural washing from lands. The following exhibit gives the result:

River.	Natural wash.	Wash from mines.
Upper Sacramento	2,100,000	
Feather and tributaries	1,800,000	9,700,000
American River	1,000,000	3,500,000
Total cubic yards	4,900,000	13,200,000

To recapitulate: There were in the past year 18,100,000 cubic yards of material brought down the Sacramento Valley in suspension by the river waters. Of this 4,900,000 cubic yards was due to natural wash, and 13,200,000 yards directly to mining operations. Of the whole, 2,100,000 escaped into or settled in the basins, and 16,000,000 cubic yards were carried in the waters of the main river past Sacramento.

Proportions of mining sediments suspended.

From the foregoing, it may be seen that 40,564,000 cubic yards of material were put into the Feather River and its main tributaries, by the hydraulic mining process during the past year; and I have estimated that 9,700,000 cubic yards of this passed out in suspension—about 24 per cent. Also, that 8,604,000 cubic yards of material were put into the American River cañons; and I have estimated that 3,500,000 cubic yards of this amount were carried out in suspension—about 40 per cent.

The first result is in every way satisfactory, and about what might well be expected. The second requires some explanation.

It will be noticed that a comparatively large allowance has been made for the natural wash from the American River mountain watershed. This has been done because there is a much greater area of cultivated ground there than in any of the basins tributary to the rivers further north, and because the surface is in great part a red soil easily washed, and furthermore, the large number of old abandoned mines along the river's bluffs and banks furnish a great quantity of very fine sedimentary wash with every heavy storm, which has no parallel in the other regions with which it is compared; and the whole country moreover is more cut up with roads and paths,

where dust is formed to be washed down in winter. So much for the natural wash.

The materials put into the American River are of a lighter nature, contain more top soil on the average than those of the Feather, Yuba, Bear, or any other stream now being considered. At some points almost the entire washing sometimes is in this red soil, which all goes off in suspension. At other points where the material is heavier, the great fall which it has into the deep cañons and the immense pulverizing power of the floods there, grind it to the finest atoms, and thus it is carried up in the waters. The fine character of the material washed in the river is shown to a degree by the extraordinarily high duty which the water performs—4½ cubic yards to the 24-hour inch, on the average, as against 3 and 3½ cubic yards in other quarters.

I am now bought to a point where it is well that the subject of storing the sands in the cañons be considered.

RESERVOIRS FOR THE SANDS.

It has been shown that the damage resulting from the flow of mining detritus is for the most part caused by the sands which are pushed along the bottoms of the streams. Could these sands be withheld from the cañons, or could they be there stored and not permitted to escape into the valley, the damage would be in a great measure averted. Hence, the effort should be towards the accomplishment of this end, for either the sands must not be put into the cañons, or being deposited there, they must be kept from coming down into the valleys. In some cases doubtless they can be withheld and reservoired in side ravines, cañons, or valleys, but I am not prepared to say where.

Dams must be the chief remedy.

The chief remedy is to be found in storing the sands in the cañons of the mountain rivers, and this can generally be accomplished by means of dams constructed of heavy masses of stone, quarried from the overhanging and adjacent cliffs, and dumped in rough massive structures across the gorges.

In this matter I have made a special study of the Yuba River, which is the receptacle of a much greater quantity of detritus than any other stream in the State; so that if it can be established that the effort to hold back and store these injurious materials upon it will be successful, the inference is fair that a similar result may be expected on the other streams, for there is much less to provide for upon them, and the opportunities for holding it are equally favorable, so far as I am at present informed.

Detritus reservoirs on the Yuba.

A survey of the Yuba River for 85.5 miles from its mouth up its main, south, and middle forks within the mountains, was made during the autumn of 1879, under my direction. A fuller account of the results of this work will be found in Appendix A, to this part of my report. The objects of the survey were to ascertain the present condition of the river and lands where covered with detritus, the present condition of the cañons into which mining tailings are dumped, and to study the matter of storing these tailings and preventing the

flow of sands and sediments therefrom into the valleys, and the streams thereof. The dimensions and grades of the cañons were ascertained by instrumental survey and measurements as accurate as are ever made for preliminary purposes, and the results are to be relied upon.

Dam and reservoir sites.

In the course of this survey special examination was made of such points as seemed to present favorable sites for the construction of dams and the storage of detritus behind them; the result is that six points were selected of which studies were afterwards made in detail, with the view of ascertaining the probable cost of the dams and the amounts of material which they would retain behind them. The outcome of three of these studies is now presented in a comprehensive form in the table which next follows:

STORAGE OF DETRITUS.

Showing proposed dimensions and probable costs of dams for the retention of sands, and volume of material which will be stored thereby in the cañons of the YUBA RIVER.

NAME.	Elevation of foot of dam above tide	Grades.			Dimensions of dam.						Cost of dam.		Storage capacity of reservoir	Cost of retaining one cubic yard of debris	Cost per cubic yard mined out
		Above	Below	Proposed above	Height	Length of crest	Width of crest	Upper slope	Lower slope	Contents, cubic yards	Per cubic yard	Total cost			
Bridgeport	482	30 M. Yuba	22	20	50	267	45	$\frac{2}{3}$	$\frac{1}{3}$	57,754	$1 00	$57,754	11,582,000	$0.0049	$0.0034
Bridgeport		50 S. Yuba		16	40	380	40	$\frac{2}{3}$	$\frac{1}{3}$	82,562	1 10	90,818	30,000,000	0.0030	0.0021
Bridgeport				14	40	493	35	$\frac{2}{3}$	$\frac{1}{3}$	108,395	1 20	130,074	50,433,000	0.0026	0.0018
Bridgeport				12	40	606	30	$\frac{2}{3}$	$\frac{1}{3}$	132,553	1 30	172,319	75,000,000	0.0023	0.0016
Bridgeport				10	40	721	25	$\frac{2}{3}$	$\frac{1}{3}$	154,991	1 40	216,987	96,500,000	0.0022	0.0015
Totals and averages					210					536,255		$667,952	263,515,000	$0.0026	$0.0018
Union Bar	310	22	22	20	50	442	45	$\frac{2}{3}$	$\frac{1}{3}$	106,713	$1 20	128,056	17,860,000	0.0071	0.0050
Union Bar				16	40	555	40	$\frac{2}{3}$	$\frac{1}{3}$	128,922	1 30	167,600	20,103,000	0.0083	0.0058
Union Bar				14	40	668	35	$\frac{2}{3}$	$\frac{1}{3}$	153,909	1 40	215,473	26,918,000	0.0080	0.0056
Union Bar				12	40	781	30	$\frac{2}{3}$	$\frac{1}{3}$	176,285	1 50	264,427	37,179,000	0.0071	0.0050
Union Bar				10	40	894	25	$\frac{2}{3}$	$\frac{1}{3}$	196,757	1 60	314,811	62,800,000	0.0050	0.0035
Totals and averages					210							$1,090,367	164,860,000	$0.0066	$0.0046
De Guerre	123	15	15	15	10	5,200	20	$\frac{2}{3}$	$\frac{1}{4}$	207,100	$1 40	289,940	32,465,000	0.0089	0.0062
De Guerre					10	5,300	20	$\frac{2}{3}$	$\frac{1}{4}$	114,833	1 50	172,250	35,415,000	0.0049	0.0034
De Guerre					10	5,350	20	$\frac{2}{3}$	$\frac{1}{4}$	115,151	1 60	184,242	36,498,300	0.0050	0.0035
De Guerre					10	5,400	20	$\frac{2}{3}$	$\frac{1}{4}$	116,235	1 70	197,600	37,500,000	0.0050	0.0035
Totals and averages					40					553,519		$844,032	141,878,300	$0.0059	$0.0041
Grand totals and averages												$2,453,779	528,671,300	$0.0046	$0.0032

Dams on the Main Yuba.

This table shows the result of estimates made for storage of sands by dams projected at locations on the Yuba River—that is, below the junction of the South Fork.

Three studies are exhibited: one for a dam, located about a quarter of a mile below the junction of the south and main Yuba Cañons, and calculated to back the material up into both. This is called the Bridgeport Dam, as it is located one and one-quarter miles below the river crossing known by that name.

The next is for a dam located seven miles further down the river, and a short distance above the junction of Deer Creek. This is called the Union Bar Dam, and is calculated to back the material up to the site of the first dam and raise it there fifty feet.

The third is for a dam located at De Guerre Point, about 6.4 miles below the Timbuctoo or Big Ravine dumps, and 11.1 miles above the mouth of the river at Marysville. This is called the De Guerre Dam, and is calculated to back the material up to the foot of the Smartsville dumps.

The first two sets of dams are estimated upon to a total height of 210 feet each; the third, to a height of forty feet. The first two are comparatively short dams, and are projected at points within the cañon proper; the third is a long, low dam, across a rather narrow part of the spread of sands at the edge of the hills, between two outlying points thereof.

Primary points and plans.

The primary points in this whole matter of dams, are (1) to put material enough in an embankment across a cañon to resist, as a whole, the moving force of the water and the pressure of the solid matter which will be brought to bear upon it; and to have that material, where exposed to the action of the running waters, of such heavy and massive pieces that each such part will withstand the shocks to which it will be subjected, without being moved from place.

The exact form which such a dam should take may be an open question, and perhaps would always be governed greatly by local circumstances, such as the character of the foundation, the shape of the cañon, and the kind and convenience of location of the rock available. And, furthermore, as this is a matter which, if begun, must, under present circumstances, continue on for some time, the experience gained each year will point the way for subsequent action. Hence, I do not at this time propose any exact plan in detail for a dam or series of dams, which I am prepared to espouse as the best. But I estimate liberally upon one project, and remark that a variation in the details of form or arrangement need not greatly change the quantity of material required.

The proposed Union Bar and Bridgeport dams.

Each of these proposed structures spoken of as a dam is really a series of dams in succession. The upper two series are projected to be built fifty feet high at first, and then four additions of forty feet each. Taking the Union Bar dam as an example, the following is a description of *one method* of building it:

At its proposed site the cañon is about 300 feet wide on the present level of the sand and gravel bed with which it is filled, and the slopes

of the sides are at about 35 degrees from the horizon, with cliffs of rocks standing back above. It is proposed to quarry the rock from these cliffs, transport it down the hillside, and use it in the construction of a loose but massive dam, and add to this, from time to time, as the necessity therefor becomes apparent, thus making a series of dams, one above another. The first dam of the series is projected with a crest or top 45 feet wide (up and down stream); slope down stream, 1 on 3; slope up stream, 2 on 3. It would be 442 feet long from hill to hill on the crest, and 270 feet through on the base up and down stream.

This estimate is made upon the plan of commencing the second dam when the material has filled to within 5 feet of the top of the first; and to allow for settling and foundation, the second dam is estimated fifty feet in elevation also, but the total height credited to the two is placed at only 90 feet. The second dam is projected as resting partly on the first dam, and partly on the material that will have accumulated above it. Thus the down stream face of the first is continued up for the second dam, on the same slope (1 on 3), to an elevation of 40 feet perpendicularly above the top of the first. The top of the second dam is projected at 40 feet in width (up and down stream), and its up-stream slope is taken at the same as that for the lower or first one, namely, 2 on 3. It will be seen that the second dam will then be 220 feet through, up and down stream, on the level of the top of the first; that it will rest for 50 feet on the first, and above that, up stream, on the material which shall have lodged behind it for 175 feet; and that, extending below the level of the top of the first, it will be embedded behind it, as it were. And in this manner each dam is projected on top of the one preceding, until the fifth is reached at 210 feet of elevation, with a crest of 25 feet wide on top and 894 feet in length, the whole presenting a uniform slope on the down stream face of one on three.

An alternative plan of construction.

The foregoing plan contemplates the construction of one high rapid, as it were, on a slope of one on three, down which the water would spread in a sheet. Another plan would be to break up this fall into successive pitches, each probably of steeper incline than that mentioned, and with a heavily paved apron at the foot thereof. Thus, each succeeding dam in a series could be set about one hundred feet up stream from the one already in place, and its down stream foot connected with the crest of that below it, by the rock apron spoken of. The estimate admits of such a disposition of the material.

By this arrangement the waters would be broken up more in their movement, and their force destroyed, or at least a great accumulation of it prevented.

There is a possibility also that it might be found advisable in practice to vary somewhat from the dimensions as to height which I have estimated upon, and instead of having the dams fifty and forty feet high, make them forty and thirty feet in elevation. These changes, however, would not alter the result greatly in the matter of cost.

It should be understood that these dams would not be built 40 or 50 feet high in any one year, or even hold water behind them to any such depth. It is probable that they never would be so constructed as to hold water behind them more than 25 feet in depth, and may

be not over 15 feet. Certainly the higher dams would not, but additions would be made from time to time, as occasion required.

Points in construction.

There are three lines to be guarded in a dam of this character. (1) Being a loose mass of great stones filled in with smaller fragments, the water would at first percolate very freely through it, until the lodgement of gravel and sand checked this escape, which it would do in a great degree. Now, the heavier masses of stone admit of the greatest percolation, and having the widest interstices, the time necessary for filling them would be longer. These percolating waters must not be permitted to wash the sands of the foundation from under and around the individual pieces or masses of the dam and permit them to settle; hence the whole structure should be set upon a bed of small stones, whose interstices would rapidly fill and stop the running waters next the sand bed. Especial care should be taken in this regard, both at the up stream and the down stream footing of such a structure. Again: (2) The *return wash*, as it is called, must be guarded against at the down stream foot of the structure, and to this end a massive stone apron about one hundred feet or more in width, to receive the waters below the dam, should be provided, and the down stream edge of it should be guarded by a deeper layer, sunken somewhat in the manner of a sunken wall. And, as the third point to be looked to, (3) care should be exercised in adjusting the masses of stone along the crest of such a structure, in a manner that no opportunity be offered for the concentration of the waters at any one point; that is to say, the top should be made level, kept free from considerable depressions, and the heaviest masses of stone placed there to insure a successful resistance to the force of the running waters.

It will be observed from the tables that the longer dams of the series are made with thinner crests. A reason for this is apparent, and it illustrates an important point in this whole matter. The waters of a flood which on a bed 250 feet wide run 10 feet deep, will fall over a crest 750 feet long with considerable less than one-third that depth; so as these structures are raised and become longer on their crests, by reason of the cañon opening out wider, they will not be subjected to such powerful action along their top lines, for the waters will run over them in thin sheets, and hence can be made lighter—about as projected. There are other reasons, also, why the lower dam of such a series should be heavier than those above it, which will suggest themselves to those who reflect upon the relative stress and comparative shocks to which they all would be subjected.

Stability of dams.

The above are three principal matters of detail to be looked to in such a construction, and of course they should be adjusted with a very wide margin for safety, so that by no possibility may anything but a favorable issue ensue. And the same thing may be said concerning the adjustment of the mass of the dam itself, and the selection of the material of which to build it. Very large masses of hard rock—five, ten, and even fifteen tons in weight each—must be at hand for the finishing work, and a quarry that would not turn out a great deal of its stone in quite large pieces would not be a favorable one from which to construct such a dam; for not only the crest, but

the down stream slope, and the apron, also, must be composed largely of these big masses, which can only be handled by the heaviest steam derrick, or rolled over by machinery.

It is to be remembered that these dams are not intended to stand for a long time under constant pressure with water behind them, and are not to be considered as subject, from like cause, to the casualties that occur sometimes to such structures. The reservoirs behind them are expected to fill up with sand and gravel, and then the dam becomes merely a facing to a hillside over which the water falls.

Precedents in the matter.

The construction of stone dams to be subjected to the action of torrents is not an untried experiment, neither is the location of a stone dam upon a sand and gravel foundation a new thing. In India there are numbers of instances where masonry dams across large rivers are built upon sands, and in the case of one structure across the Cauvery—a river larger than any of ours—which had stood for centuries, so far as known, an examination of it, as we are told by Mr. Baird Smith, in his work on Irrigation in the Madras Provinces, revealed the fact that it was constructed of rubble stone and clay only. If dams are ever put into the streams as suggested here in California, they must be put there to stay, and if the work cannot be executed so as to insure this end, as far as human foresight can insure anything, it ought not to be done. I am of the opinion that this can be accomplished, and substantially, in the manner above described.

I do not know that these proposed works have exact precedent now in existence. Dams for substantially the same purposes, and constructed in about the same manner, have been in place for years in some of the provinces of the Upper Rhine, and in France. These were constructed in the smaller mountain torrents to diminish their grades and prevent the wash of gravel down upon valuable estates below. And then there are the instances cited concerning the construction of dams in India on sand foundations across monster rivers. There are also dams in our own mountains, on a small scale, which are performing the office sought to be fulfilled by the proposed works on the larger rivers. Beyond these, and some similar instances, we have nothing to go by in the matter; but then nearly all engineering works are experiments to some degree, particularly those which are intended to cope with some active force in nature, as hydraulic constructions generally are, so that such works are often carried forward with a tentative policy and guided by experience constantly being acquired.

The proposed De Guerre dam.

The De Guerre dam, as said before, is projected as a long, low structure of loose stone across a narrow part of the sand-flat, at the edge of the foothills. The stone is to be quarried from the adjacent hills and transported to the dam site on a small tramway and there dumped in a low causeway, as it were, 20 feet wide on top with slopes of two on three up stream, and one on four down stream. Each dam in the series has been projected in the estimate, 10 feet in height, and the four, which make up the 40 feet, are of equal width and height. In the estimate for the first dam of this series is included material for a heavy apron of stone, and an allowance is made in each instance for foundation and settlement.

Cost of materials.

In estimating on these dams, it is observed that the cost of material is graded up higher from the first dam to each succeeding one in a series. This has been done because the great consumption of material will make it necessary to transport it further for each succeeding work, and because the increasing length of the crests of the higher dams of a series will also necessitate greater transportation to their midway points and handling of the rock. While the rates fixed per cubic yard are not extravagantly high, it is believed they are ample to pay for good work, if favorable quarries are to be found, for be it remembered that all material quarried will be used, except the smallest broken stone and dust or litter.

Order of building dams.

I am not prepared to say that the points selected are absolutely the best places for dams. They are good points, and a little inspection of the ground and study, when, if ever, it is proposed to commence construction, will point out exactly the best localities. It will be necessary to construct at least a very low dam at the lower site; perhaps it will appear that one five feet in height will answer for present purposes at this locality, if at the same time the first dam of the series above is built.

Retention of the Sands.

By reference to the table, it will be seen that the existing grade of the river bed at the proposed Bridgeport dam is twenty-two feet per mile; at the Union Bar dam site it is the same. The sands now found resting upon that grade, held there by the obstructions below. I take it, therefore, that if artificial obstructions, in the form of heavy stone dams are placed in their way, these sands certainly will rest behind them on the same grade. But, to be on the safe side, I have estimated upon lighter gradients; so that in the case of the two upper dams considered, the slopes in the channel upon which it is assumed the sands will rest above them, are gradually reduced to the close of each estimate—when the dam is projected at a total height of 210 feet—and the sands are supposed to have assumed a grade of only ten feet per mile above the obstruction. And it is believed they will remain there at that grade, even when the supply shall have in great measure ceased.

At the lower or De Guerre reservoir site, the sands are now on a grade of fifteen feet to the mile; the channel is already broad above, and will not be made materially wider by raising the surface forty feet, so that it is believed the sands will stay upon the same grade above it, and the estimate is so made. In speaking of the material which will stay behind these obstructions, it has been called *sand* because chiefly of that nature, but it must be understood that cobble stones and gravel will enter largely into its composition.

Grades above dams.

I am very well aware that upon raising the plane of the bed of a stream in a cañon, and thereby securing a wider surface for the waters to run upon, we might expect to secure greater grades in the ground line. It would be the natural action in a sediment-bearing river to increase the grade when its breadth is increased with the same volume of water present; but in the present instance other matters are

to be considered. In the first place, commencing with a grade of 22 feet per mile, we must anticipate the lodgment of a lighter material behind these dams than now rests in the bed of the streams where this slope exists, and consequently we cannot expect it to assume such a heavy grade. And in the next place, the grades now in existence in these cañons are maintained by the constant large supply of material at the upper end, but we must look forward to the time when this supply in a great measure will cease. When, for instance, the Union Bar Reservoir shall have been filled, and it is proposed to construct another dam at some point above, perhaps at the Bridgeport site, the supply to the lower reservoir must in great measure cease, otherwise the upper one will not be performing its duty. In the estimate, therefore, it is presumed that the grades above the dams will gradually grow less as the dams are raised, and to say the least, if this supposition is not absolutely correct, it is certainly an error on the safe side.

Amount of material to be stored annually.

In former pages hereof I have shown that 22,326,500 cubic yards of material are placed in the Yuba River annually. I have also shown that probably about 24 per cent. of this is carried down the main river in suspension. It is to be presumed that the remainder is rolled along the bottom of the channels, and left in scattered deposits all down its course.

For present purposes I assume it as reasonable that of, say, 23,000,000 cubic yards annually, 70 per cent. can be stopped behind dams, and that 30 per cent. will go out in suspension. Seventy per cent. of 23,000,000 is 16,100,000, and this is the number of cubic yards of material to be stored each year.

Storage capacity.

Consulting the table already explained, it is seen that the Bridgeport series of dams, or dam as it may be called, will hold back as projected 263,515,000 cubic yards, the De Guerre dam 141,878,300, and the Union Bar dam 164,860,000 cubic yards, a total of 570,253,700. From this total is to be subtracted about 40,000,000 cubic yards taken out of the head of the Union Bar reservoir by the Bridgeport reservoir, and we have a capacity of, say, 530,000,000 cubic yards; sufficient to hold the heavier materials of the flow at the rate of 16,000,000 cubic yards per year for 32 years, and this would represent a total volume washed out by the mines of 755,000,000 cubic yards.

It is not to be understood that this exhausts the storage capacity of these cañons, for it is far beyond that estimated upon thus far. Doubling the height in a series of dams of either the Union Bar or Bridgeport dams will triple their retaining power. This can be done without interfering with any of the mines in the case of the lower dam of the two, and without material interference in the case of the upper one; always providing that suitable material can be quarried convenient to the proposed sites of the works.

Cost of retaining detritus—Yuba River.

Next to the last column of the table shows the probable cost of this work per cubic yard stored; and the last column shows the probable cost per cubic yard necessarily mined out in producing the 70 per cent for storage. This cost, it will be observed, ranges from fifteen

hundredths to sixty-two hundredths of a cent—from one and a half to six mills, per cubic yard sent down by the mines.

The total cost, exclusive of the cost of the first two dams in the Bridgeport series, which would be rendered unnecessary by the construction of the Union Bar dam backing the material up there, is $2,453,779. This would show an average cost of four and six-tenths mills ($0.0046) per cubic yard stored, three and two-tenths mills ($0.0032) per cubic yard mined out.

To all engineering estimates it is the custom, and of course a proper one, to add a percentage varying from 5 to 20 per cent. for miscellaneous expense and contingencies. In the present instance I add 20 per cent.

In the case of the Union Bar reservoir there would not be any property damage until the last 80 feet were put on to the dam. In the case of the De Guerre and Bridgeport reservoirs there would be some interference with small farms or gardens at an earlier period in the progress of their filling. It is difficult to estimate what this will amount to, without a special examination and inquiry into the matter, which has not been made; but in my judgment $50,000 would be an extravagant recompense for all harm done to such property.

Making these allowances then, the total expense of these projected works will be $2,894,534. Calling this sum three millions of dollars, the expense would be at the rate, on the average for thirty years, of one hundred thousand dollars per annum. Of course this representing the average expense over a long period of time, the first cost will be greater, and will thereafter diminish gradually to the end; thus the first year $150,000, and thereafter graded down to $50,000 at the end of the term estimated for. I have endeavored to place this estimate upon a liberal basis, and I now submit it as worthy of confidence, so far as I am able to make it so.

Probable cost of reservoiring the sands.

Upon all of the foregoing, as a basis, I estimate that to deal in the manner described with the detritus coming down the Feather, Yuba, Bear, and American Rivers, it will cost during the next thirty years, seven millions of dollars—an average of about $233,000 per year.

Treatment for Table Mountain and other Creeks.

The above is the principal work of this character to be done. To hold back the sands in Table Mountain Dry Creek, in Butte County, will not cost nearly so much per cubic yard mined, so far as I am able to judge by the examinations thus far made. The dams there would be low embankments of earth and brush bundles, and the material would by their action be stored in the low, flat valleys of the foothills.

A similar treatment would probably be advisable for Roseville and Auburn Ravine Creeks, but I have no data upon which to give an opinion in these cases. It should be remembered that all of the creeks mentioned drain into low basins, back from the rivers, and their sands do not damage these great veins of the valley drainage system; but there is a considerable property damage threatened, to avert which some action in the matter of holding back the sands and confining the mud-laden waters is necessary; but this I am not able to estimate upon for the want of data.

Preliminary expense.

In concluding this subject of the probable cost of storing the detritus in the cañons, I remark that at the commencement of all considerable works there is always an unavoidable outlay for a *working plant*, or outfit, and for other items which, in the case of a small work, would count up heavily against it and add greatly to its cost. So in this instance should work be commenced on any of the dams spoken of, a heavy outlay would be necessary for appliances specially suited to the service, which would last partially through a series of years. And whether the work were undertaken by contract, or by day labor, this expense would equally have to be met, for the contractor would charge to cover all his expense of this kind, seeing that it would be in a great measure for a special outfit, and transportation would be a large item.

Estimate for first year.

The Yuba, Bear, and American Rivers are those most requiring attention in the preservation of the interests of the State, and the greatest valuation of private property. Now, should it be deemed desirable to attempt to ward off the danger which exists from the sands and gravel in the beds of these rivers, I estimate that it will be necessary to expend $600,000 during the first year.

Effect of the sand reservoirs.

The foregoing has been directed exclusively to a consideration of some method of storing the sand and gravel—the *heavy material* as it is called. Should such works be commenced, the benefits would not become immediately apparent; there would be little change in the appearance of the streams on the average through the year. During low stages the waters would be somewhat clearer, because they would deposit much of their sediment behind the dams. But the first freshet would probably sweep out a large portion of the very light sediment thus placed in the reservoirs, particularly when in any case they were nearly full of sand; neither is it altogether desirable that the light sediment should stay behind the dams, for they would occupy the space needed for the sands and gravel, which are so much more to be feared in the streams below. It should be clearly understood, therefore, that the object and effect of these proposed dams would be to hold back the sands and gravels, and not the finer sediments which discolor the waters.

Diversion of low water flow.

In this connection I call attention to the fact, as shown by the observations made, that nearly as much very fine sediment is brought out of the cañons during what may be called the low stages of the streams, as in their high stages, and that by the diversion of the waters when at the low stages, and consequently manageable in quantity, a very large amount of the sediments could be conducted in canals to settling reservoirs in the rolling lands at the edge of the foothills, or spread over the plains in irrigation. I estimate that one-third of the light material which is brought out of the mountains could be disposed of in this way; and, as I believe, if used for irrigation, to the benefit of the lands irrigated. This subject of irrigation with sediment-bearing waters is spoken of more at length in a

paper on irrigation already submitted, being Part IV of this report. It is only necessary to remark here that, where used properly in irrigation, the waters carrying these sediments are preferable to clear water on most soils, except retentive clays. There is abundant evidence of this fact now to be found in the State, although apparent evidence to the contrary is produced. Wherever I have looked in the matter, however, I have found, when bad results follow, that the water was not used by any good system, and the ground not cultivated as it should be. Such muddy waters are sought after for irrigation in the south of France; and in other quarters of that country, where the streams are clear, propositions have been seriously entertained and extended examinations conducted to determine the cost of improving lands by the use of waters artificially made muddy in the mountains, for the purpose; and this, too, with soil not fertile when cultivated where deposited to any depth greater than that at which it can be turned under with the plow.

Diversions into low basins.

I have, in Part II of my report, under the head of drainage, spoken of the possibility of disposing of much of the sediment in the rivers by turning a part of their waters into some one or more of the low swamp basins for settlement. This matter belongs more to the subject under which it was first mentioned, for it would have to be taken up as a part of a general system of drainage. The plan would be efficacious under proper management, for the purpose named, but it would not correct the great evil—the flow of sands which move along the bottoms of the streams; nor could this evil of the sands be remedied by any diversion of the lower river waters, except the entire stream were turned, which is a work of great magnitude and doubtful propriety.

CONCLUSION.

Owing to the lateness of the day at which I have been enabled to complete thus far and submit this part of my report, I do not feel justified in consuming time in endeavoring to further elaborate the plan of relief proposed, or to bring out other and collateral projects. Suffice it to say that in my opinion:

Hold back the sands.

The sands and gravel can be held back and stored in the cañons and in the flats at the mouths of those cañons, substantially in the manner described.

There is a necessity for doing this to keep more of these heavy materials, particularly the gravel, from being brought out into the valley streams.

There is a necessity for a sustained treatment of the Bear and Yuba Rivers between the foothills and their mouths in order that they may once more be brought to a fixed alignment, and not to be permitted to wash the sands and gravel by which they are surrounded into the main streams below.

All of this can be done; and in view of the interests at stake and good to be accomplished—the prosperity of the hydraulic mines, the protection of the City of Marysville from serious disaster, and the City of Sacramento from injury more remote; the shielding

of a large area of valuable agricultural land from serious damage; and the preservation of the great streams of the valley from an almost irreparable injury—I believe I am justified in saying that it can be done at an expense much within the limits of the benefits to be derived, and the danger averted.

The streams must be treated.

But it must not be understood that the simple withholding of the sands from the valleys will accomplish all that should be tried to insure these results, although that is the first thing to be done. I have pointed out in a former part of this report that a sustained and systematic treatment of the drainage lines of this State is a necessity, and I have endeavored to outline such a treatment. Holding back the sands is the first step. It must be followed by some treatment of the large streams to insure any noticeable good results to them within a reasonable period of time. While I cannot say that the same absolute necessity exists for this improvement of the stream channels at once that, in my opinion, does exist for holding back the sands, I do say that the Sacramento and Feather Rivers are just in a condition wherein, as the result of a great flood, they may leave their present channels and take possession of one of the low basins by which they are flanked, though this time may prove to be quite remote.

Legislation.

I am required to state "what legislation, if any, will be effectual in preventing the rise of the beds" (of the rivers), "or in diminishing the rate of rise."

It is impossible for me, not possessed of full facts in this matter, or with time at my command, to do justice to such a question, even granting that I was possessed of the ability so to do.

I can only say that legislation which will provide for the construction of works designed to prevent the sands and gravel from coming into the valley streams, and which will provide for the systematic and sustained treatment of the rivers of the valleys to prevent the unnecessary spreading of their waters, will be effectual, and will accomplish the desired end.

Very respectfully submitted.

WM. HAM. HALL,
State Engineer.

APPENDICES TO PART III.

LETTER OF TRANSMISSION.

Office of the State Engineer,
Sacramento, California, March 5th, 1880.

William Hammond Hall, Esq., State Engineer:

Sir: Acting under your instructions, I have made various surveys of the Yuba River and its main tributaries. The general results and data collected during these surveys, are herewith submitted.

The surveys from Smartsville dumps to the mouth of the river were conducted during the months of March and April, 1879. On the 6th of September, following, I received instructions to continue this work up the mountain cañons of the river, which was done in conjunction with the City of Marysville and the Hydraulic Miners' Association. To the representatives of these corporations, Mr. Geo. F. Allardt, C. E., and Col. A. W. Von Schmidt, I would respectfully tender my thanks for their courteous coöperation and kindness.

The work connected with these surveys was at all times arduous, and frequently dangerous; much credit is therefore due to Messrs. W. M. Fitzhugh and S. L. Dolsen, and to the other members of the party, for their sacrifice of personal comfort, and for their continuous and faithful exertions under circumstances which were never favorable.

I remain, sir, very respectfully,

MARSDEN MANSON,
Assistant Engineer.

[APPENDIX A.]

REPORT ON THE SURVEY OF YUBA RIVER AND ITS FORKS.

BY MARSDEN MANSON, ASSISTANT ENGINEER.

YUBA RIVER.

GENERAL DESCRIPTION.

Before entering upon an account of the Yuba River surveys, a short description of the general features and character of the river is necessary. This river has its rise on the western slopes of the Sierra Nevada Mountains. It drains about 1,329 square miles of territory lying in Nevada, Yuba, and Sierra Counties. The extreme length of this watershed is 60 miles, and its extreme width 36 miles; to this length must be added about 11 miles of channel through the plains to the mouth at Marysville.

Yuba River is a tributary of Feather River, entering this stream 29 miles above its mouth. In point of size Yuba River ranks fourth of the rivers of the Sacramento Valley; its extreme low water discharge is 500 cubic feet, mean winter discharge about 1,500 cubic feet, and flood discharge 26,000 cubic feet per second. Its drainage basin may be divided into five smaller ones, viz.: North, Middle, and South Forks; Deer and Dry Creeks. Of these, the first mentioned is by far the largest, and has the greater general elevation. All but the last unite in the foothills; and this joins the main stream just as it leaves the foothills—entering from the north side 12.75 miles above the mouth of the Yuba. The forks definitely examined are described from the highest points reached in the examination, to their mouths.

THE SOUTH FORK OF YUBA RIVER.

Of the three main forks which unite in the Sierra Nevada Mountains to form the Yuba River, that which bears the name of the South Fork is the second in size. It drains a watershed of about 306 square miles of mountainous territory, whose elevation is from 480 to 8,000 feet. Like all mountain rivers, the South Fork is quite tortuous in its course, and rapid in its descent. Its general direction is a few degrees south of west, flowing almost diagonally across Nevada County.

Initial point of survey.

The highest point on the river reached by the detailed surveys and

examinations by this department is 31 miles above its mouth, where its bed is about 125 feet wide, and composed of large granite and gneiss bowlders, with but few bars of movable material. The elevation above low tide in the bay, at this point is 2,666 feet, and the average grade of the stream 56.35 feet per mile. The sides of the cañon are coarse granite, much broken. The mountain slopes are sparsely timbered; fir, spruce, and pine predominating, with a few oaks and the usual bushy undergrowth. None of the trees are of large proportions, and are only seen on the northern exposures where the snow lingers late in the spring, and the rocks are covered with soil. Southern exposures are generally devoid of vegetation. At the point mentioned (where our description of the river begins), Omega Creek enters the cañon on the left side. This stream, which discharges but little water during the late summer and fall, presents the appearance of having brought down mining detritus, scattering beds of which still remain. The winter flow is used for hydraulic mining, but the season when it can be thus used is but a few months in duration each year.

Limit of hydraulic mining.

Above the mouth of Omega Creek no mining operations of importance have yet been carried on, and it is reported to be at the upper limit of the great gold-bearing deposits adjacent to the South Yuba. A few quartz mines exist above, but they have been, in the majority of instances, abandoned.

Below Omega Creek.

About three-quarters of a mile below the mouth of Omega Creek the cañon widens out in places to 1,500 feet, with flats on each side — benches slightly elevated above the stream. These flats continue for a distance of two miles, in the center of which on the left bank is located the Village of Washington, a small mining settlement, supported by the adjacent placer workings. At the upper end of these flats are several paying gravel mines, one of which uses the hydraulic process, and discharges tailings into the river above Washington. On, and immediately below the dump of this mine, there was estimated to be 6,700 cubic yards of fine detritus, in a condition to be swept down the channel with the first freshet. A number of gravel mines in the flat are worked by Chinese; one of which, directly opposite Washington, is owned by a large and thoroughly organized Chinese company, who mine with great system, use water-power hoisting machinery, and seem to be in a very prosperous condition. The general grade through this portion of the river is 54 feet per mile.

The cañon below Washington.

For the first 1¼ miles below Washington, the sides of the gorge gradually converge and become more precipitous in slope; the benches on either side of the river channel are dotted with piles of bowlders regularly laid, marking the position of former placer workings, which are being reworked here and there by scattering groups of Chinese miners, who are also in some instances opening up new claims. In this reach of the river enter Scotchman's and Washington Creeks, the latter carrying a comparatively small amount of detritus from the Alpha mine. Both streams are small, and have a very slight low

water discharge, too insignificant in volume to be available for hydraulic mining. Two and one-half miles below Washington there commences a very narrow and steep portion of the cañon, the width of channel-way being reduced to about 100 feet; the grade decreases to 41.5 feet per mile. Masses of coarse granite and slate form the rugged and precipitous walls. This condition continues for half a mile, when the cañon again widens and resumes a more gentle grade and less forbidding appearance. Flood-waters rise in this gorge some 25 feet above low stage, and have sufficient force to sweep out all material to the more open reaches below. In the open reach below this rugged portion of the cañon, the left bank is heavily timbered with oak and red fir. The low bars in the bed consist of cobbles of an older appearance than those lower down. Four miles below Washington a slight brush dam across the river diverts water into a small flume on the right bank, for use in a drift mine half a mile below. The mine being situated below high water mark, cannot be worked during flood seasons. For 4.4 miles below this mine, or to within 21.5 miles of the mouth of the South Fork, the general character of the cañon remains the same, the grade being irregular, but not exceeding 35 feet per mile, the bed consisting of coarse material, with low bars of cobble stones here and there on either side. One important ravine enters on the right side; its mouth is marked by a deposit of coarse detritus, brought down from the mines at Relief Hill. There are indications showing that a much greater deposit has existed at this point, but which has been swept down stream by high water. Below this ravine large piles of bowlders, on both sides, show that placer mining has been extensively carried on in the past.

Detritus from the North Bloomfield mines.

Twenty and four-tenths miles above the mouth of South Yuba, Humbug Creek enters from the right. At the time of the examination, in October, it was discharging about 2,500 miners' inches of water, heavily laden with detritus from the North Bloomfield mines. This detritus has accumulated in the mouth of the creek, filling its bed for some distance up, throwing a broad dam across the river channel, whose width at surface of low water has been increased from about 150 to 350 feet. The depth of the detritus is at least 30 feet. The dam creates a large pond of still water above it, backing the water for nearly half a mile. In the first 1,100 feet below the dump at Humbug Creek, the deposit in the river bed is estimated at 694,500 cubic yards. It is composed of every grade of material from cobbles six to eight inches in diameter down to impalpable powder. At least one-half of that in sight was of a character readily swept out by floods. Rims of crusted sediment on the sides of the cañon indicate that the deposits have reached a greater depth than now, and have been swept out by the freshets of recent years.

Humbug Creek to Sailor Flat dump.

From Humbug Creek to the dumps of the Sailor Fat and Blue Tent hydraulic mines, a distance of 2.54 miles, the cañon has been much filled up, and aside from the larger mass immediately at the first named point, it is estimated that about 287,300 cubic yards of debris is deposited in the bed of the river. The way is lined with high bars of cobble stones on either hand, their interstices packed with sand

and gravel. The dumps of the Sailor Flat and Blue Tent mines are on the left bank, about 500 feet apart. The upper dump—that of Sailor Flat—is composed of fine and coarse gravel and sand, discharged down a narrow ravine which is much choked up. The lower dump is composed of much heavier material, brought down a ravine so steep and precipitous that the material seems rather to descend the face of the cañon, in a series of cascades, the water dashing wildly from one series of "undercurrents" and "riffles" to another, forming a spectacle which might be considered beautiful, but for the muddiness of the water and the ceaseless grinding and pounding of the rocks swept along by the current. The heavy material of this dump serves as a temporary backing for the finer detritus above, giving it a more secure lodgment to resist further transportation down the stream. For three-fourths of a mile above the dumps the water is backed up by the dam they create, and fine quicksands, dangerous to traverse, are deposited over the entire bed of the cañon. Occasionally the dam partially breaks way releasing the confined waters, which rush down the cañon with great violence, imperiling the lives of those who may chance to be in its way. The surveying corps of this department had several such experiences, much to their chagrin, when they were forced to suspend operations until the freshet had subsided. The volume of detritus lodged in the vicinity of these dumps was estimated at 200,000 cubic yards, all of which was considered liable to be swept out by floods. Past deposits have existed four and one-half feet higher than the present ones, as shown by the lateral drift or crusted rims of similar material adhering to the sides of the cañon.

Sailor Flat and Blue Tent dumps to Edwards' Bridge.

From these dumps to Edwards' Bridge the distance is 1.55 miles. The width of channel way is about 150 feet, and the deposit over the entire distance is reported to be five to twenty feet deep, the total volume of which is estimated at 152,000 cubic yards. Low bars of cobble stones have been piled up on either side by high water, and are frequently cut into by low water channels. They are in every way similar in appearance to those below Humbug Creek. Just below the two large dumps described are two smaller ones, that have apparently been in position many years. Down the side ravines through which they came trickled streams of clear water. Edwards' Bridge spans the cañon at a point 16.5 miles above the mouth of South Fork, on the line of the Nevada City and North Bloomfield road. The elevation of the floor of the bridge above tide is 1990.6 feet; low water of 1879 and flood-water mark of 1862, are at elevations of 1954.7 feet and 1973.5 feet, respectively, above low tide plane.

Edwards' Bridge to Purdon's Bridge—4.05 miles.

For 1,800 feet below Edwards' Bridge the cañon presents a natural appearance, with only the former pools filled with detritus grading the slope to a nearly uniform fall of 71.24 feet per mile, the deposit probably not exceeding 7,500 cubic yards.

The normal condition of the cañon does not continue a greater distance, but deposits of considerable depth are found all along, becoming coarser as the stream is descended, till the dump of the Columbia Hill mines is reached. At this point the cañon is about 100 feet wide, and the evidence of past deposits are to be found in the fragmentary rims clinging to the sides of the gorge, twenty feet above

the present low water elevation. The cañon below this dump is not so much filled, and in places presents the clean appearance incident to all such contracted gorges, where the confined waters even in their lowest stage have the power to sweep along all manner of detritus to lower reaches. The total amount of deposit between the two bridges is estimated at 76,000 cubic yards.

Purdon's Bridge to head of Jones' Bar—5.08 *miles.*

A narrow, precipitous, rock bound cañon characterizes the South Fork the entire distance from Purdon's Bridge to Jones' Bar, the river having a grade of 80 to 106 feet per mile. The bottom and sides, when not composed of the rock *in situ*, is made up of huge rough masses which have broken off and fallen in from above. The quantity of mining debris lodged in this section of the river channel is slight, and estimated at 31,000 cubic yards.

A log and stone dam 1.91 miles below Purdon's Bridge diverts about 3,000 inches of water into the Excelsior Company's flume and ditch. The flume winds along the side of the cañon, in places apparently hanging to the face of the wall, and finally passes over the ridge at the head of Kentucky Gulch, hundreds of feet above the river opposite.

Jones' Bar.

Just below the mouth of the long narrow cañon described, the mountain sides are further apart, have flatter slopes, and descend to the river with low, rounded hills, sparsely wooded. The channel is 500 to 600 feet wide, and bordered by low benches of land, sloping back at light angles to the foot of the hills. This open space, nearly a mile in length, is known as Jones' Bar, and has been the scene of considerable placer mining in the past. The grade of the river for this distance is about 60 feet per mile, and the area of the bar is considerable, so that by constructing a dam across the narrow cañon at its lower end, it could be converted into a reservoir for the storage of mining detritus. The quantity now lodged along the bar is estimated at 231,500 cubic yards. At the lower end of the bar a ravine called Rush Creek, draining three square miles, enters from the left.

Jones' Bar to mouth of South Fork—6.27 *miles.*

This portion of the cañon is somewhat wider than that above Jones' Bar, and has generally a heavier grade, as will be observed by reference to the table of grades found at the close of this paper. Several small streams enter the river in this distance, the most important of which are Shady and Little Shady Creeks. The former, rising near Cherokee Hill, joins the river 5.9 miles above its mouth. Shady Creek drains an area of 16 or 17 square miles. Large quantities of mining debris are reported to be stored in its bed, by means of low brush dams. Little Shady Creek is a much smaller stream, and is only worthy of mention as the channel through which the detritus from the French Corral series of mines is dumped into the river, at a point 4.87 miles above the mouth of South Fork. This same series of mines discharge detritus into the river three miles above its mouth; it is here brought into the river almost down the side of the cañon. The debris at this point is piled in the river, obstructing its flow, and, like the dam at Sailor Flat and Blue Tent dumps, causing a deposit of fine quick-

sands above, increasing the width of the stream to 175 feet. The depth of this deposit is said to be 30 feet, and consists of 50 per cent. of cobbles, and the remainder of sand and gravel—all liable to be swept out at high water. Here, as elsewhere throughout the cañon, the evidences of more extensive deposits, that have been carried down stream, are to be seen. Below this point, to the Bridgeport reach, the cañon is too narrow and contracted to afford lodgment for any great amount of detritus.

Bridgeport.

The teaming station of Bridgeport is located one mile above the mouth of South Fork, on one of those open flats sometimes met with in descending the river. The main road from Smartsville to North San Juan, and the upper portion of Nevada and Sierra Counties, crosses the river at this point. Kentucky Creek enters from the left bank 460 yards below the bridge, and 0.72 mile above the mouth of South Fork. Low flats on either side of this creek adjoining those of the main stream are covered with orchards, vineyards, and gardens. At this point the river averages 300 feet in width, but its channel is much choked with mining detritus, and the filling is reported to be from five to ten feet at the upper end of the reach above the bridge, and about 30 feet at the lower where the South Fork joins the Main Fork. By the erection of a high dam across the main stream below the junction, these wide flats about Bridgeport, as well as those on the Main Fork, would afford a large area for the storage of mining detritus flowing down both Forks of the Yuba. The location is a favorable one; the cañon narrows to a width of 125 feet below the junction, and the material for construction is abundant in the cliffs on either side. Should this barrier ever be carried to a height of 250 or 300 feet, a permanent overflow channel in solid rock can, without doubt, be readily made around one of the small mountain spurs on the left bank, thus avoiding the passage of the water over the top of the dam.

THE MIDDLE FORK OF YUBA RIVER.

As implied by its name, this stream lies between the two other forks of the Yuba. It unites with the North Fork about eight miles above the mouth of the South Fork—the united rivers forming the Yuba. Its watershed is about three-fourths as large as that of the South Fork, and occupies the southern portion of Sierra and the northern portion of Nevada Counties—the stream being the dividing line between the two counties, and having a general direction sensibly parallel to the South Fork.

The survey of the Middle Fork was commenced on the 29th of September, 1879, at the crossing of the pack trail from Moore's Flat to Minnesota Hill. The stream is here crossed by a single span bridge 85 feet between the abutments and 14 feet above the level of low water. This bridge is known as the Moore's Flat Bridge, and is some 18 miles in an air line from the summit of the Sierra Nevada Mountains, and by way of the river about 32 miles above the mouth of the South Fork. The sides of the cañon are not much broken, and slope evenly at angles of about 35 degrees with the horizon. The formation is slate, whose disintegration has given the mountain sides a smoother appearance than is common where more indestruct-

ible and harder stone is found. The mountain sides are covered with a growth of brush which only occasionally gives place to pine and oak.

The general width of the bed of the stream is 100 feet, and the bottom and sides have an entirely natural appearance—there being no indication of an unnatural deposit. The water at the time of the survey was cool, pleasant to the taste, and nearly clear; the rolling of pebbles along the bottom was distinctly observed through six inches of water. The elevation of low water above mean low tide in the Bay is 2,884 feet; the sides of the cañon rise to about 4,500 feet above tide.

No extensive hydraulic mining operations have been carried on above the initial point of this survey, although gold-bearing gravel deposits exist some five miles above on the Sierra County side of the river.

Old deposit of mining detritus.

Three hundred yards below the Moore's Flat bridge a small ravine enters from the left bank; rims of gravel and sand adhering to the sides of the ravine and of the river mark the limits of a past deposit of mining detritus, and show that it once extended entirely across the river, with a length of about 500 feet, and a depth at the mouth of the ravine of 12 to 15 feet, and 8 to 10 feet deep opposite, sloping gradually down to the surface of low water. No material had been brought down the ravine for some time.

Moore's Flat dumps.

There exists a second dump 1,000 feet below the one just mentioned. The deposit of detritus here is of more extensive dimensions, and appears to be more recent, although none was being brought down at the time of survey. It was discharged down the steep side of the cañon in a similar manner to that at the Blue Tent dump; about 6,000 cubic yards remain in the bed of the river. The character of the deposit is the same as that in the dumps upon the South Fork, with the slight exception of a whiter appearance of the sand and gravel.

Effect of the hydraulic mining process upon the water of the river.

At 11 A. M. of the 29th September, when at a short distance below the dump just mentioned, a rumbling noise was distinctly heard and recognized as being produced by the water and detritus pouring down the side of the cañon at the dump. The concussion of the cobble stones as they bounded down was readily recognized. The river water below the dump had been previously nearly clear, and similar to that at the bridge above; but as soon as the water from the mine reached the river a change was at once produced, its water became very muddy, and too highly charged with suspended mineral water to be used; from a very potable water it was immediately changed so as to be entirely unfit for use.

For 7,900 feet below the dumps the character of the river bed is different from that above; it becomes wider, averaging about 125 feet, with low bars of cobble stones on either side; the low water channel meanders from one side to the other over bars of similar material. The depth of deposit is, however, slight—probably not averaging over two feet, representing a total deposit of 73,100 cubic yards, 25 per

cent. of which is fine material, and in a condition to be washed out by freshets. At the lower end of this distance a ravine enters from the left bank which has brought in a considerable amount of material from the same series of mines. At the mouth of this ravine the probable depth of the deposit is 20 feet, and with the following dimensions: length, 800 feet; width, 500 feet; slope from left to right, $\frac{1}{20}$; it has two deep channels cut through it—one by the ravine water and the other by the river; both have banks eight feet high. The channel cut by the river was evidently cut during flood water, as low water is still forced against the right bank in a narrow stream. The quantity of material remaining here is estimated at 30,000 cubic yards, one-third of which is liable to be swept out by flood waters.

Woolsey Flat dump.

Just below the ravine above mentioned is a second, which, from its position, is thought to discharge the detritus from Woolsey Flat mines. This ravine brings down a very fine quality of white sand, similar in all appearances to that upon the Sailor Flat dump, except its superior whiteness. The predominance of fine material enables this dump to spread out more than those above, and its abundance to interfere seriously with the flow of the river, which it forces against the right bank. The dimensions of this dump are as follows: Length, 1,000 feet; average width, 300 feet; probable depth, 20 feet; contents, about 222,000 cubic yards—seventy-five per cent. of which is liable to be swept out by floods. The material here has the appearance of having been more recently deposited than that upon the dump above. No fresh material was being deposited upon either at the time of examination.

From Woolsey Flat dump to San Juan Dam.

The distance along the cañon from Woolsey Flat dump to the San Juan Dam is 1.74 miles. For the first 1.3 miles the cañon is about 200 feet wide, with low bars of cobble stones on each side, filling one-half to two-thirds of the water way. It is estimated that 259,800 cubic yards of detritus find lodgment in this stretch. The sides of the cañon become more rough and the growth of trees upon the left side becomes more dense. The right side remains comparatively bare. The remainder of the distance to the San Juan Dam is through a rough, precipitous cañon, whose sides and bottom are composed of coarse granite rock. No material of moment is lodged in this except about 5,800 cubic yards just back of the San Juan Dam.

San Juan Dam.

This dam is built of stone and logs bolted to the bottom and sides of the cañon. It is about seven feet high, and during low water throws nearly all the water in the river into the head of the San Juan flume and ditch, a large portion is, however, at once turned back into the river through the sand gates. The flume is fastened on to the side of the cañon, and carries about 1,100 miners' inches of water to the San Juan mines. A short distance below the dam a portion of the flume is enlarged into a settling tank of the following dimensions: Length eighty feet, width twenty feet, depth five feet. The water in passing through this tank has its velocity decreased to such an extent as to cause the deposition of a portion of the sand held in suspension, and which would fill up the ditch in parts where lighter

grades and greater sectional area exist. The tank when about two-thirds full of sand, is discharged back into the river through suitable gates. This occurs about twice or three times a day when the mines above are being worked, and seldom or never during intervals when they are not being worked. An insignificant deposit of sand occurs where the tank and sand gates discharge.

San Juan Dam to Freeman's Bridge—15.32 *miles.*

From the San Juan Dam to Freeman's Bridge the distance is 15.32 miles. There are many variations in the cañon in this distance, and many very tortuous changes in its direction, affording excellent points of study for the geologist, also diversities in the size and character of the deposits in the bed of the stream—to describe each minutely would incumber this report, and unnecessarily increase its proportions.

Small tributaries.

The small tributaries which enter the river between the two above mentioned points are Bloody Run and Grizzly Creek, on the Nevada or left side; and Kanaka, Indian, and Oregon Creeks from the Sierra and Yuba County side. Bloody Run empties 1.11 miles below San Juan Dam; it is a small, clear stream, discharging only a few miners' inches. Kanaka Creek is 2.11 miles lower down; during the early fall it discharges about 200 miners' inches of water. It is charged with a slate-blue sediment somewhat different from that in the waters of the Yuba, and not apparently present in quite so great a proportion. The drainage area of this stream is about nine square miles.

Indian Creek discharges into the Middle Fork 1.76 miles below the mouth of Kanaka Creek, and 10.34 above Freeman's Crossing. It is a beautifully clear stream, with a low water discharge of about 250 miners' inches.

Grizzly Creek enters 5.04 miles above Freeman's Bridge; it has an unimportant drainage area and discharge, but is rendered important from being the channel down which the detritus from the Cherokee Flat mines is discharged into the river. The mouth of the creek and the river bed adjacent are much filled up, the total depth of filling in the river being about 30 feet.

Dump of the Columbia Hill mines.

Just below the mouth of Grizzly Creek mining detritus is also discharged into the river down a series of fall sluices and undercurrents from the Columbia Hill mines. The material discharged from these two sources fills the entire bed of the river, forming a dam similar to that at Sailor Flat and Blue Tent dumps. Above this dam for the space of 3,000 feet there was, at the time of survey, a quicksand deposit. There had been at these dumps a much greater deposit of similar material than was there at the time of the examination, as was evidenced by the remains of it on the sides of the cañon. These marks of the former deposit were near the mouth of the creek, 31 feet above the water in the river, and slope gradually down to the present river bed, intersecting it at a distance of 1,200 feet below the mouth of the creek. Estimates of the quantity of deposit in the bed of the river are found in Table B. Below these dumps the deposits in the bed of the river are coarser and more extensive than above.

Emory's Flat.

Somewhat over two miles above Freeman's Bridge, there exists a broad flat space between the sides of the cañon, known as Emory's Flat. Quite extensive mining operations were once carried on here, and a bridge crossed the stream. The mines are now abandoned to a few Chinese, and the bridge is gone. The length of the flat is about 2,500 feet, with a width of 700 feet. Its general elevation is about fifteen feet above low water. Back of the flat the sides of the mountains slope at angles of about fifteen and twenty degrees. Low ravines enter on each side, whose rise near their mouths is comparatively slight. They have flats of a very limited area adjacent to their mouths. Below Emory's Flat the sides of the cañon close in upon the river, forming a narrow gorge, across which a rough stone dam could be thrown, utilizing the space above for the storage of debris.

Oregon Creek.

This narrow steep cañon continues nearly to the mouth of Oregon Creek, which enters 2,100 feet above Freeman's bridge. This creek has a drainage area of about eighteen square miles, and discharges, during low water, about 250 miners' inches. Its waters are darker in color than those of the Yuba, but apparently not so heavily charged with sediment.

Character of the river and cañon near Freeman's Bridge.

Freeman's Bridge is on the main line of road from Smartsville and North San Juan to Camptonville and Downieville. On the right bank of the river is a hotel and teaming station. The mountains stand well back for a distance of nearly a mile up and down the river, and the space between them and the river bank is occupied by low rolling hills or gently sloping flats. For 4,100 feet above and 4,700 feet below the bridge, the bed of the river is from 200 to 600 feet wide. The grade of the river here is about 60.4 feet per mile. The present elevation of low water at the bridge above mean low tide in the Bay, 1,698 feet. This space could be utilized for the storage of detritus by the construction of a dam across the narrow part of the cañon, commencing 4,700 feet below the bridge.

Freeman's Bridge to the Junction of the Middle and North Forks.

Throughout the distance from Freeman's Bridge to the junction of Middle and North Forks, 4.18 miles, the cañon is very rough, and in places precipitous to a dangerous degree to persons attempting to pass through it. But little debris finds lodgment in it, except that at American dump, near which point it is estimated that some 300,000 cubic yards remained. This material enters from the left bank 3.45 miles below Freeman's Bridge, and 0.64 mile above the mouth of the Middle Fork. It is discharged down the side of the cañon from bench to bench of undercurrents, and finally enters the river through a short tunnel cut in a low spur; undercurrents and "riffles" extending very nearly to within reach of high water. Here, again, there exist marks of greater deposits which have been swept out by flood waters. Just below the American dump the sides of the cañon close in upon the river with steep rocky bluffs, giving the cañon an impassable, not to say dangerous look. In this no debris of moment remains at any stage of the river. This has a width of about 100 to 150 feet. Its bot-

tom and sides are of huge masses of rough stone; it continues to the junction and further, as described below.

MAIN FORK OF YUBA RIVER.*

Junction of the Middle and North Forks to the South Fork.

The North and Middle Forks unite at a point 4.18 miles below Freeman's Bridge, and about 8 above the mouth of the South Fork, forming the main Fork, and thence flow together for about 4.5 miles in a cañon whose forbidding wildness cannot readily be pictured in words. The depth of this gorge is from 1,200 to 1,500 feet, its granite walls rising precipitously from a bed of bowlders whose width rarely exceeds 125 to 200 feet. The roughest part of the cañon proper is quite tortuous in alignment, is about 4.5 miles in length, and is very precipitous in descent. Except at very low water it is almost unapproachable, and even under the most favorable circumstances one who would pass through it must be prepared to wade the stream successively from side to side, as his progress would be frequently interrupted by a vertical wall of rock with no friendly ledge along which to crawl. Such being the character of the cañon, it need scarcely be said that no mining debris of moment has found lodgment there, except that which has filled the crevices between the immense bowlders. Where the North Fork joins the Middle Fork, nearly at right angle to its course, a bar of small bowlders has been piled up in the channel, above which, and almost on the side of the cañon, a drift of sand has lodged. The height at which this material is here found clinging to the sides of the cañon, and that at which drift-wood was observed, seems to indicate that the waters have risen at several points at least 40 feet above the bed.

Manzanita Hill dump.

The Manzanita Hill Mine dumps its material into the Main Fork 1.19 miles below the mouth of North Fork, down a short and very precipitous ravine entering the stream from the left. Notwithstanding the almost constant discharge of tailings from this source, the quantity of detritus remaining in the bed at that point is but a few hundred cubic yards, and a short stretch of the cañon, 1,000 feet long and 100 feet wide, is filled (at low water only) to a depth of perhaps two to four feet, commencing at a point 300 feet below the dump. There are evidences to show that even this small amount finds only a temporary lodgment, and is swept out clean by even a slight rise of the waters. Just below the wild box cañon described, the river widens out, at Missouri Bar, to 250 or 300 feet, with occasional reaches of 500 or 600 feet. There are narrow, gravelly benches on either side, slightly elevated above low water. The mountains fall back, giving the sides of the gorge much flatter slopes. This condition is maintained to the junction of the Main and South Forks, a distance of about three miles. The deposit of mining detritus is estimated at 35 feet in depth at the lower end of this section, decreasing to nothing at the upper end. Between these two points—the lower end of the bad

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* The distances from the Dumps of the Manzanita Hill Mines to the mouth of the South Fork are not given from definite surveys of this Department, but from the Township maps of the United States Land Office. The surveys of the State Engineer Department were not extended below the point abovementioned, owing to the lateness and inclemency of the season.

cañon and the mouth of South Fork—three small streams enter the river from the north, two of which are characterized by flat side slopes, light grades, and low flats on either side of their channels, extending for some distance back from the river, marking them out as desirable points for the detention and storage of debris. The grade over this stretch of the river is regular and uniform—about 30 feet per mile—and the bed is filled up to this grade with coarse cobbles at the upper end for one half or three-quarters of a mile, the material decreasing in size to very coarse gravel, mingled with occasional cobble stones, to the lower end—at the mouth of South Fork. This coarse material is packed together with finer quartz pebbles and sand, which fill all the interstices and form a comparatively smooth and compact bed.

YUBA RIVER.

Mouth of the South Fork to the Yuba Mill and Mining Company's shaft—13.6 *miles.*

The original river bed from the mouth of the South Fork down is entirely filled up with mining debris; the water flowing on top of the deposit of detritus and confined by the sides of the mountains rather than by its original banks. The reported depths of this deposit, as far down as the Yuba Mill and Mining Company's works, (a distance of 13.6 miles) were as follows:

At the mouth of the South Yuba	30 to 40 feet.
Three miles above Deer Creek	40 feet.
At the mouth of Deer Creek	80 feet.
At the Smartsville dumps	125 feet.
At the mouth of Timbuctoo Ravine	80 feet.
At the Yuba Mill and Mining Company's shaft	75 to 80 feet.

The general character of the river in this division is more gentle than at any point heretofore described. The grade line is more regular and even. The sides of the cañon slope at generally lighter angles, and only now and then do the bluffs close in upon the river.

As far down as Timbuctoo Ravine, or three-quarters of a mile above the Yuba Mill and Mining Company's shaft, the average width is from 300 to 400 feet, ranging between extremes of 125 to 550 feet. Below this ravine the width increases to 1,000 feet in the widest places.

The character of the material deposited in this division of the river is as follows: The greater portion in sight is fine quartz gravel and sand; the distribution of cobble stones is by no means regular; at the mouth of the South Yuba they constitute about 15 per cent. of the deposit; they become fewer and more scattering as the stream is descended, and disappear about 2¾ miles above the mouth of Deer Creek; they are brought down by Deer Creek, and form a large proportion of the material which fills the mouth of that stream and the bed of the river just below; they disappear about a mile above the Smartsville dumps; but upon and below these dumps, for the rest of the way to the Yuba Mill and Mining Company's shaft, they form a large part of the deposit. There are, however, two sources below the Smartsville dumps which supply coarse detritus, namely: the Timbuctoo Ravine, on the left bank, and Sicard Flat mines on the right bank. These last mines discharge detritus into the river 0.9 mile above the Yuba Mill and Mining Company's shaft, and are the last source of coarse material. Scattered over this distance, and

indeed up the South Fork, to the mouth of Humbug Creek, are a few blocks of partly carbonized wood, or lignite; this is generally of a crumbly nature, but is sometimes compact enough to be worn into rounded shapes. There also occurs a white and yellow efflorescence of sulphate of magnesia, traceable wherever there are extensive beds of mining detritus.

Small tributaries.

The tributaries entering in this reach of the river are comparatively few; Deer Creek is the only one of moment. It drains some 65 square miles of territory and empties into the Yuba from the left bank 7.57 miles below the mouth of the South Fork. It has several hydraulic mines situated in its basin; the only one examined is known as the Deer Creek claim, and belongs to the Smartsville series of mines; it discharges detritus into Deer Creek a short distance above its mouth.

In the tables appended to this report are found the distances, grades, elevations, and estimates of the material deposited in the bed of the river, throughout this division. The general grade is quite uniform, being from 22 to 23 feet per mile. The increased width of this division, and its lighter grade, make it a favorable portion of the river in which to retain the debris yet to be brought down. There are points at which projecting bluffs offer material for the erection of rough dams for this purpose.

Yuba Mill and Mining Company's shaft to the Mouth of the Yuba—fifteen miles.

The river rapidly widens below the Yuba Mill and Mining Company's shaft, until at a distance of seven miles above its mouth, it has a width between levees of 2.8 miles. It then contracts, irregularly in width, and flows into Feather River during flood periods with a width of from a mile to a mile and a half. Through the greater portion of the distance, of 15 miles, between the Yuba Mill and Mining Company's shaft and the mouth, the river flows in changeable and narrow channels, over a large territory of former bottom lands. Through this it originally had well defined banks, but at present these and the adjoining lands have been covered from one to twenty feet deep with mining detritus. A description of this territory is unnecessary here, as it is found elsewhere. The material hereon deposited is principally sand; at the upper portion coarse gravel and even cobble stones are found; in the high water channels fine gravel was observed within three miles of Marysville. Much of the deposit in the lower portion is fine clay, frequently too wet to venture upon. In many places the effloresced salts of magnesia, heretofore spoken of, exist in sufficient quantities to destroy the flags and willows.

Four and a half miles below the Yuba Mill and Mining Company's shaft there juts out from the right bank a rocky point named De Guerre Point; it is some 40 or 50 feet high, and narrows the width of the river to about a mile. Opposite De Guerre Point there are high slopes, rising gently to a height of 100 or 150 feet above the bed of the river. A low dam across this narrow portion of the river would retain a large amount of mining detritus. The outcropping of stone on each bank of the river warrants the belief that an abundance of material is close at hand for such a structure. Below this point the high lands gradually merge into the plains, the levees commencing 2.75 miles below on the right bank, and 2.25 miles below on the left bank.

TABLE A.

Showing the results of estimates of the quantity of mining detritus lodged in the cañon of the South Fork of Yuba River, below the mouth of Omega Creek.

Locality.	Quantity, cubic yards.
Dump of Small Mine above Washington	6,700
At and below Humbug Creek	694,500
Above quicksands at Blue Tent dump	133,300
Quicksands above Blue Tent dump	154,000
Blue Tent and Sailor Flat dumps	200,000
Cañon above Edwards' Bridge	152,000
Just below Edwards' Bridge	7,500
Below dumps of Columbia Hill	68,500
Cañon above Jones' Bar	31,000
On Jones' Bar	231,500
From Jones' Bar to French Corral dumps	132,900
French Corral dumps	115,000
Cañon above Bridgeport	30,000
Bridgeport to near mouth	1,444,300
In the mouth	445,000
Total in the South Fork	3,851,200

TABLE B.

Showing the results of estimates of the quantity of mining detritus lodged in the beds of the Middle and Main Forks of Yuba River, below Moore's Flat Bridge.

Locality.	Quantity, cubic yards.
Old dump, 900 feet below Moore's Flat Bridge	6,000
To below Moore's Flat dumps	103,100
Woolsey Flat dumps (mouth of Bloody Run)	222,000
To the San Juan Dam	265,600
To near the mouth of Indian Creek	47,300
Indian Creek to the mouth of Grizzly Creek	683,900
From Grizzly Creek to Emory's Flat	853,000
Along Emory's Flat	300,000
Cañon below Emory's Flat	22,000
To head of cañon, 4,700 feet below Freeman's Bridge	199,000
Cañon above American dump	52,000
American dump, and below	300,000
Total	3,053,900

TABLE C.

Showing the results of estimates of the quantity of mining detritus lodged in the bed of the Yuba River, from the mouth of the South Fork to Marysville.

Locality.	Quantity, cubic yards.
From the mouth of the South Fork to three miles above Deer Creek	4,665,300
From three miles above Deer Creek to Deer Creek	7,700,000
From Deer Creek to Smartsville dumps	7,306,600
From Smartsville Dumps to the upper end of the dump at Timbuctoo Ravine	12,392,200
From the upper end of the Timbuctoo Ravine to the Yuba Mill and Mining Co.'s works	6,200,000
From the Yuba Mill to county bridge, at Marysville	23,284,000
Total	61,548,100

RECAPITULATION.

In the South Fork	3,851,200	
In the Middle Fork	3,053,900	
In the Main Fork	3,293,000	
In the Yuba to the Yuba Mill	38,264,000	
		48,462,100
In the Yuba below the Yuba Mill		23,284,000
Total		71,746,100

RIVER OBSERVATIONS.

Season of 1878-1879—*Upper Yuba* (*above Forks*).

Location.	Distance from New York, miles	Distance from preceding station, miles	Elevation of low water above base, feet	Elevation of high water above base, feet	Difference between high and low water, feet	Low and High Water Profiles. Low water. Difference in elevation of low water, station to station, feet	Low water. Fall or slope per mile, feet	High water. Difference in elevation of high water, station to station, feet	High water. Fall or slope per mile, feet
Main and Middle Fork.									
Junction of South and Main Fork	137.56		484.5	496	11.5				
Mouth of Middle and Main Fork	145.61	8.05	1,203.9	1,228	24.1	719.4	89.37	732.0	90.81
Freeman's Bridge, Middle Fork	149.79	4.18	1,527.0	1,540	13.0	323.1	77.29	312.0	74.64
Emory's Old Crossing—remains of old bridge	152.61	2.83	1,698.0	1,710	12.0	171.0	60.40	170.0	60.05
Grizzly Creek	155.55	2.93	1,879.0	1,893	14.0	181.0	61.8	183.0	62.5
Opposite upper end of Grizzly Ridge	158.74	3.19	2,156.0	2,167	13.0	277.0	86.52	274.0	85.58
Half mile below Kanaka Creek	161.56	2.82	2,276.0	2,288	12.0	120.0	42.5	121.0	42.9
Quarter mile above Bloody Run	163.77	2.21	2,454.0	2,468	14.0	178.0	80.5	180.0	81.4
Foot bridge between Alleghany City and Moore's Flat	169.26	5.49	2,883.0	2,894	11.0	429.0	78.1	426.0	77.6
South Fork.									
Mouth of South Fork	137.56		484.5	496	11.5				
Two and one-third miles below Little Shady Creek	139.44	1.88	622.0	635	13.0	137.5	73.13	139	73.93
Half mile below Little Shady Creek	141.92	2.48	871.0	884	13.0	249.0	100.40	249	100.40
Seven hundred feet below Shady Creek	143.39	1.47	999.8	1,011.8	12.0	128.8	87.62	127.8	87.00
Half mile below Purdon's Bridge	149.36	5.97	1,633.4	1,646	12.6	633.6	106.13	634.2	106.21
Edwards' Bridge	153.87	4.51	1,954.7	1,964.4	9 7	321.3	71.24	318.4	70.60
North Bloomfield dumps (mouth of Humbug Creek)	157.98	4.11	2,187.4	2,201.4	14.0	232.7	56.62	237.0	57.66
One and one-fifth miles below Missouri Cañon	160.35	2.37	2,268.0	2,283	15.0	80.6	34.01	81.6	34.43
Two miles below Washington Creek	163.56	3.21	2,401.4	2,414	12.6	133.4	41.56	131.0	40.50
One-fourth mile above Washington Creek	165.85	2.29	2,508.4	2,522	12.6	107.0	46.72	108.0	47.16
Four-fifths mile above Washington	167.84	1.99	2,627.0	2,640	13.0	118.6	59.59	118.0	59.29
Omega mining dump	168.55	0.71	2,666.0			39.0	56.35		

RIVER OBSERVATIONS.

Season of 1878-1879—*Yuba River, from the mouth to the Forks.*

Location.	Distance from New York, miles	Distance from preceding station, miles	Elevation of low water above base, feet	Elevation of high water above base, feet	Difference between high and low water, feet	Low and High Water Profiles. Low water. Difference in elevation of low water, station to station, feet	Low water. Fall or slope per mile, feet	High water. Difference in elevation of high water, station to station, feet	High water. Fall or slope per mile, feet
Mouth of Yuba River	108.19		49.48	67.16	17.68				
Foot of D Street, Marysville	108.44	0.25	52.09	67.16	15.07	2.61	10.60	0.00	0.00
Bridge on Marysville and Wheatland road	109.02	0.58	55.07	67.16	12.09	2.98	5.16	0.00	0.00
Opposite Dunning's	110.61	1.59	63.77	68.80	5.03	8.70	5.47	1.64	1.03
Opposite Hamilton's	111.97	1.36	71.27	74.40	3.13	7.50	5.50	5.60	4.11
Opposite Mrs. Pumyear's	114.98	3.01	88.29	91.30	3.01	17.02	5.65	16.90	5.61
Opposite Drumm's place	116.08	1.10	95.25	97.70	2.45	6.96	6.34	6.40	5.83
Opposite west end of Old Rule place	116.97	0.89	103.71	105.60	1.89	8.46	9.50	7.90	8.88
Opposite Cemetery	118.20	1.23	113.16	116.50	3.34	9.45	7.68	10.90	8.85
Opposite west end of island opposite Hallet's	119.89	1.69	126.11	130.00	3.89	12.95	7.68	13.50	8.01
Opposite Roan's	121.53	1.65		145.80				15.80	9.59
Five hundred feet above Old Mill	122.61	1.08		163.90				18.10	16.77
Yuba Mill and Mining Company's shaft	123.90	1.29		190.40				26.50	20.58
Two thousand feet below Timbuctoo dump	125.23	7.33		217.70				27.30	20.58
Two thousand feet above Timbuctoo dump	125.91	0.68		237.00				19.30	28.31
One and one-fourth miles above Smartsville dumps	129.73	3.82	302.00	313.00	11.00			76.00	19.89
One mile above Deer Creek	131.16	1.43	332.00	344.00	12.00	30.00	20.00	31.00	20.70
One and one-half miles below Union Bar	132.37	1.20	358.50	370.70	12.22	26.50	20.10	26.70	22.20
One-third mile below Union Bar	133.57	1.20	386.00	401.00	15.00	27.50	22.91	30.00	25.25
One and three-fourths miles above Union Bar	135.69	2.13	435.50	455.00	19.50	49.50	23.24	54.00	25.35
Mouth of South Fork	137.56	1.87	484.50	496.00	11.50	49.00	26.20	41.00	21.92

LETTER OF TRANSMISSION.

OFFICE STATE ENGINEER,
SACRAMENTO, California, March 3d, 1880.

William Hammond Hall, Esq., State Engineer:

SIR: I have the honor to submit herewith a report upon the examination of the samples of sediment-bearing waters taken from certain rivers of the Sacramento Valley during 1878–9. Accompanying the report are: (1) The note book used in the work, in which will be found in detail the circumstances under which each sample of water was taken, the quantity of sediment found in each, etc. (2) Tabulated statements of the results of the sediment examinations. (3) The material found in each sample separately placed in vials and arranged according to rivers and localities. The operations of separating, drying, and weighing the sediment, were conducted at the laboratory of the University of California. The thanks of the Department are due to Professors Hilgard and Rising, and to Drs. John and Joseph LeConte and their assistants, for the interest they manifested in furthering the progress of the work, as well as my own acknowledgments for the courteous kindness I received at their hands.

Very respectfully,

MARSDEN MANSON,
Assistant Engineer.

[APPENDIX B.]

REPORT ON DETERMINATIONS OF SEDIMENT HELD IN SUSPENSION

AND

Transported by the Waters of Certain Streams of California.

MARSDEN MANSON, ASSISTANT ENGINEER.

SEDIMENT DETERMINATIONS.

For the purpose of ascertaining the volume of sediment held in suspension and transported by the principal rivers of the Sacramento Valley, a number of samples of the water were taken at various times during 1878–79. These samples were generally taken in groups, in order to obtain a fair average of the stream. The stream was divided into two or more sections, and in each a sample of the water as it flowed was generally taken at the surface, at mid-depth, and at the bottom. The average of all the samples in each group gave a mean for the whole stream. It was the aim to have a complete series of samples for the more important streams—particularly those receiving detritus from the mines—at extreme high and low stages, and at medium flood, but this was not in all cases accomplished.

The apparatus used for obtaining the samples having been described in Part I of your own report, further allusion to it here is unnecessary. It can only be added that the working of the hydrophores was thoroughly satisfactory so far as securing a fair sample of the water as it flows is concerned.

The whole number of samples obtained was 242, distributed among the streams as indicated in the following pages. Aside from these there were also taken for examination and comparison 44 samples of soils and deposited sediment.

Treatment of water samples.

To determine the quantity of sediment by weight and volume held in suspension, it was first essential to separate it from the water. The samples were, therefore, allowed to stand in the air-tight jars in which they had been placed, for several weeks until the suspended material had settled to the bottom, and the water had become clear. As much as possible of the clear water was then drawn off with a syphon, whose short arm curved upward at the extremity, in order to prevent upward currents of water from carrying off any of the sediment. The clear water from many of the samples was preserved for further examination, and the remaining water and sediment were transferred to a thoroughly dried and weighed filter of the best Swedish paper. As soon as all the water had passed through, the filter-paper and its

contents were placed in a drier, constructed specially for the purpose, and kept at a temperature of 100° Centigrade (212° Fahrenheit), for 12 to 24 hours, the temperature was then raised to 110° or 115° Centigrade for a few hours, after which the sediment and filter were placed in a desiccator to cool for a few minutes, when they were taken out and accurately weighed on an analytical balance.

Calculation of the ratios by weight and volume.

The quantity of water generally taken as a sample was one-twentieth of a cubic foot, or 1,416 cubic centimeters—the capacity of the principal hydrophores used. Some of the samples taken with an improvised arrangement in an emergency varied slightly from this quantity, and when this was the case the amount of water was accurately measured in cubic centimeters, and the proper reductions made in the exhibits to bring them all to a uniform standard. The specific gravity of the water was found to vary so slightly from unity that it was always considered as such. The number of cubic centimeters of water was hence equal to its weight in grammes. The weight of the separated sediment having been obtained, establishing the ratio between the weights of water and sediment became a simple process of division. The specific gravity of the sediment was carefully determined by a series of experiments, and found to be 1.4 as naturally deposited and air-dried, and 1.9 as determined by the ordinary method of weighing in water. The ratio of volumes was thus easily obtained by division.* When the sediment is deposited in deep basins it will doubtless be more compressed than in the samples used in these determinations, and consequently due allowance should be made for such compression in estimates involving the volumes occupied by deep deposits.

Arrangement of results.

In the tables which are appended herewith it has been sought to express the results of all the determinations of the sediment transported by rivers in such a form as to be intelligible to all at a glance. Instead, therefore, of expressing the ratios decimally, the number of parts (either pounds or cubic feet) of sediment in 1,000,000 parts of water have been given. To the ordinary reader this form of expression will be more tangible than that generally used by different authorities, and those who wish to see the proportion or percentage which the sediment bears to the water have only to prefix sufficient ciphers in each case to carry the figures to the millionth place of decimals.

The specimens of sediment obtained from the water have been placed in small vials, arranged in their proper order upon cards, and labeled with the locality from which each was taken, and with the ratios by weight and volume existing between sediment and water. These cards form a special exhibit, telling in a graphical and emphatic way the facts which are conveyed by the tables. They likewise show what is not shown in text—the character of sediment peculiar to each stream. The tables and samples are referred to in the succeeding pages as follows:

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* In calculating this ratio, the specific gravity of the naturally deposited and air-dried sediment (1.4) has been used, as this is the specific gravity of the material as it is to be dealt with in engineering operations. Should it be desired to obtain the ratio of the volume occupied by the sediment *in the water*, to that of the water, the divisor should be 1.9 instead of 1.4; or the absolute specific gravity of the sediment should then be used as a divisor.

Yuba River, Table No. 1; Exhibit No. 1*a* and 1*b*.
Bear River, Table No. 2; Exhibit No. 2.
American River, Table No. 3; Exhibit No. 3.
Feather River, Table No. 4; Exhibit No. 4.
Sacramento River, Table No. 5; Exhibit No. 5.
Minor streams and basins, Table No. 6.

The exhibits of sediments from minor streams are found with those of the streams to which they are tributary.

YUBA RIVER (TABLE NUMBER ONE).

Sediment from Yuba River.

There were taken from the Yuba River, between Bridgeport and its mouth, 74 samples. Of these, 30 were taken from various points above Marysville, and 44 at the road bridge at Marysville. Those taken above Marysville were selected at various points along the river from Bridgeport on the South Fork, and from Reece's Crossing, on the Main Fork, to the mouth, at Marysville. Two important sets of samples came from the waters flowing through the breaks in the levees on each bank of the Yuba River; an inspection of Table No. 1, and Exhibits 1*a* and 1*b*, show the following facts:

(1.) That the waters of the *upper* reaches of the river are more heavily charged than those of the *lower*.

(2.) That the river during *low stages is three times as heavily charged* with sediment than at *flood* stages.

(3.) That during intermediate stages the ratio of water to sediment is intermediate between the ratios existing at low and flood stages.

Deductions (2) and (3) are made more apparent by an inspection of the following table of

GENERAL RATIOS AT MARYSVILLE.

Stage.	Parts of sediment, by weight, in 1,000,000 parts of water.	Parts of sediment, by volume, in 1,000,000 parts of water.
Flood	3250	2520
High	4080	2910
Low	10260	7330

Samples taken from water flowing through breaks in levees—what they show.

On the right bank of Yuba River, above Marysville, are two nearly parallel lines of levees extending from the city towards the foothills. The outer levee, known as the Brown's Valley Grade, is used not only as a barrier against the encroachments of floods, but partly forms an elevated roadway from the low country to the high lands. Adjacent to the river bank is another embankment, called the Teegarden Levee. During the flood of February, 1879, Yuba River burst through the Teegarden Levee in a broad breach, some four miles above Marysville, and, attacking the Brown's Valley Grade two miles lower down, in turn made a break therein, through which the waters poured, spreading over the lands north of Marysville, and draining off westward into Feather River. On the 8th and 9th of March following samples of water were taken at the points where

it flowed through the breaks in the Brown's Valley Grade, where it spread over the land, and where it drained off into Feather River. In passing through the Brown's Valley Grade the water was found to be transporting 1,350 parts of sediment to every million of its volume. A few hundred yards below, as the water flowed slowly over or stood on the land, these ratios had suffered a reduction by a deposit of material, each million cubic feet of water carrying 700 of sediment; in other words, forty-eight per cent. of the material brought through the Grade was deposited on the lands as soon as the velocity was decreased. The samples taken from the water draining into Feather River showed no further decrease in amount of sediment held in suspension, nor any general washing of material from the flooded lands.

Samples from water flowing through left bank breaks.

During the March floods breaks occurred in the levees on the left bank of the river, about seven miles above Marysville, where samples of water were also taken. These samples showed that each million cubic feet of water transported 2,990 cubic feet of sediment. Comparing these ratios of sediment to water with those obtained from the samples taken on the right bank, at the breaks in the Brown's Valley Grade (1,350 parts to 1,000,000), it will be seen that the water in the river channel was more than twice as heavily charged as that passing through the Brown's Valley Grade. This difference is to be accounted for by a deposition between the Teegarden Levee and the Grade.

Samples taken from the water flowing off the land back into Yuba River, after passing through these left bank breaks, show a much greater rate of deposition than that observed on the opposite side of the river, as the sediment carried by the water was but 240 parts in 1,000,000—92 per cent. having been dropped on the way. This extreme rate of deposition illustrates the ease with which sediment can be wrung from water by checking its velocity and diffusing it in a broad shallow sheet over the land. In both cases cited the major portion of the deposit occurred immediately at the point where the waters escaped from the river channel, as shown not only by analysis of water samples, but by examination of the lands after the floods had receded.

The damage to lands by this deposit of debris on the right bank of the river was far greater than on the left, for in the one instance the waters continued to flow for months, while in the other the overflow was of comparatively small volume, and but a few days in duration; so that although the rate of deposition was greater on the left bank, while the overflow was in progress, the resulting injury to lands was but slight. The damage to growing crops was, however, about equal on both sides.

BEAR RIVER (TABLE NUMBER TWO).

Seventeen samples of the waters of Bear River were secured, one set having been taken on January 22d, 1879, the other, September 6th, of the same year. Eleven of these were from the river at the Wire Bridge, in the cañon some 25 or 30 miles below the lowest hydraulic mines; the remainder at the bridge opposite Wheatland. Both sets of samples show that a large amount of material is deposited between the two points, particularly below the mouth of the cañon, where the

river enters the valley with diminished grade and decreased velocity. The samples of January 22d, from the Wire Bridge station, show that each 1,000,000 cubic feet of water carried 10,620 cubic feet of sediment, while on the same day, at Wheatland, the ratio between the volumes of sediment and water was as 5,970 to 1,000,000, indicating a deposit of nearly 44 per cent. between the two points. On September 6th, at low water, the river was found to be much more heavily charged, although of course the total amount of sediment then being discharged was much less than in January, when the stream was full. The mean of the Wire Bridge samples, September 6th, show a ratio of sediment to water of 25,460 to 1,000,000, which was, at Wheatland, on the same day, to the ratio of 22,590 to 1,000,000, indicating that 12 per cent. of the sediment passing Wire Bridge had been deposited before reaching Wheatland.

Review of results from Bear and Yuba River samples.

As we descend these streams, the Yuba and Bear, the analysis of water shows a reduction of the rate of decrease of the volume of sediment held in suspension. As they receive no tributaries of importance between the extreme points of the examination to cause a dilution of their waters, the conclusion is plain that to account for this decrease a greater rate of deposition must be in progress at upper localities. The natural result is to steepen their grades—a tendency which is more apparent high up in the cañons, where the bed is narrow, than at their mouths, where the material has an opportunity of spreading out.

Unusual condition of Bear River.

During the low water of the past autumn Bear River was unusually clear. A short distance below the Wire Bridge, where samples were taken on the 20th of October, the bed of the stream could be faintly discerned through six inches of water; only 350 parts in 1,000,000 of water were sediment, and this principally white quartz sand. The cause of this phenomenal clearness was not known at the time of taking the samples, but it was afterwards ascertained that hydraulic mining had temporarily stopped on the tributaries of the stream above, a fact which seemed to sufficiently account for the change. The stream maintained this condition but a very short time, and during such a low stage of the river that conclusions based upon other more important facts should not thereby be modified.

FEATHER RIVER (TABLE NUMBER FOUR).

Forty-six samples of the water of Feather River were obtained at the following points and stages: Six at Oroville, during low water; fifteen at Burt's Ferry, during full and low stage; five at Marysville, during extreme flood and extreme low stages; two at the mouth of the Yuba, during low water; and eighteen at Hennessey's, near the mouth of Feather River, during full and flood stages.

An inspection of Table No. 4, and the exhibit of sediments obtained from water samples corresponding to it, to be seen in this office, show the general ratios of sediment and water existing at these points during the various stages of the river.

The samples are naturally divided into two classes—those from above and those from below the mouth of Yuba River, this stream

at all stages causing a marked variation in the quantity and quality of the suspended material found in Feather River. A comparison of Tables 1 and 4, and particularly of the exhibits corresponding to them, show this influence of the Yuba in a conspicuous way. The coarse and heavy tailings discharged into Feather River above the Yuba are not moved at low water, while during floods the natural surface washings from the great watershed of the Feather distinctly modify the character and appearance of the suspended material. On receiving the discharge of Yuba River, however, not only the color, but the texture and general character of the suspended material is altered. A careful chemical analysis would throw much light on the subject of the respective compositions of the two classes of material; but on inspection, one cannot but conclude that, from whatever cause they may proceed, the suspended matter washed down by Yuba and Bear Rivers is much more undesirable upon agricultural lands than the deposits of Feather River, which may become cultivable far sooner.

Samples from Sutter Basin.

In Table No. 6, and its corresponding exhibit, are found the results of the examination of two sets of samples of the waters of Sutter Basin—that great tract of low land lying between the Feather and Sacramento Rivers, and receiving the flood waters from both streams. They were taken about three miles above Fremont, on the 15th of May, 1879, at a time when a large amount of water was escaping from Feather River into the Basin, and flowing directly along its eastern edge into the Sacramento, and in part back into the Feather. The volume of water thus escaping was greater than the usual summer and fall discharge of Feather River, and had continued for several months previous to the taking of the samples. The samples show the presence of a comparatively small amount of sediment, there being but 160 parts in one million parts of water. The clearer water already in the basin may have diluted that from the river, but the contrary is more than probable; the samples were taken directly in the line of the current flowing from Feather River, and it is a well known fact, which every one has observed, that muddy and clear streams coming together do not readily mingle. Where the Feather and Sacramento join, the line between them can be distinctly traced for some distance, just as the waters of the Missouri and Mississippi keep apart and do not blend after coming together in one channel until they flow side by side for twenty miles or more. It is more than probable that the great difference found to exist between these samples of Sutter Basin and the average of Feather River proper below the Yuba, for the past year, is to be accounted for largely by the deposit of a large proportion of the sediment borne by Feather River waters immediately on their escaping into the adjacent basin. The extent of this deposit is shown by a comparison of the two sets of results, the average amount of sediment borne by Feather River below the Yuba being 1,200 parts in 1,000,000, while that of the Sutter Basin was, as stated before, but 160 parts in 1,000,000. In other words, 87 per cent. of the sediment carried by Feather River was deposited after escaping from the channel into the basin.

These results, which are but confirmatory of the observations on deposition from the escape waters of the Yuba before cited, are highly suggestive of the effects of passing the waters of the streams through

these low land basins, in robbing them of their suspended material. The good that may be thus accomplished is not measured alone by the amount of material that may be wrung from the waters, but on restoring them to the stream again in a clarified condition, they are given new scouring power, enabling them to attack and deepen their beds, and thus enlarge the carrying capacity of their channels. In this case, each 1,000,000 cubic feet of water escaping from Feather River was robbed of 1,040 cubic feet of sediment, and on returning to the stream endowed with power to scour and transport as much as the waters of the Sacramento River were carrying past Sacramento City—for instance, 629 cubic feet per 1,000,000 cubic feet of water.

AMERICAN RIVER (TABLE NUMBER THREE).

During 1878–79, 15 samples of the sediment-bearing waters of American River were secured, of which 13 were taken near its mouth, and two from a point four miles below Folsom. The latter were obtained during an unimportant stage of the river—low water of December, 1878—when the streams were frozen in the mountains and but little mining in progress for lack of water. The other set of samples, taken near Sacramento, generally at the Twelfth Street bridge, represent full and flood stages, and show an average discharge through the season of 4,080 cubic feet of sediment to each 1,000,000 cubic feet of water flowing. Exhibit No. 4 presents the sediment found in each sample.

SACRAMENTO RIVER (TABLE NUMBER FIVE).

During the year 1879 there were taken 68 samples of sediment-bearing water from the Sacramento River, at the following points: above the mouth of Feather River, 9; at Gray & Shaw's, below the mouth of Feather River, 6; above the mouth of the American River, 17; below the American, at the foot of I Street, Sacramento City, 12; at Freeport, 24. From the dates and discharges shown in Table No. 5, it will be seen that these samples were taken during full and flood stages. The influence of Feather River upon the Sacramento is shown by the difference, in volume of sediment carried, between the samples of Knight's Landing, above Feather River, and Gray & Shaw's below, the one showing 88 parts of sediment in 1,000,000 of water, the other 526 parts of sediment in 1,000,000 of water. Below the mouth of American River the samples reveal a further addition to the burden of sediment carried by the stream.

MINOR STREAMS, ETC. (TABLE NUMBER SIX).

In addition to the samples taken from the larger rivers named, a number were obtained from several of the following small streams entering the valley on the east from the Sierra Nevada: Wildcat Creek (a small tributary of Butte Creek); Dry Creek, near Brown's Valley; Coon Creek, Auburn Ravine, Roseville Dry Creek, Cosumnes River, and Galt Dry Creek. Most of these streams receive detritus from hydraulic mines, but the records of discharge are so incomplete, and the samples of their waters so few in number, that no satisfactory deductions can be drawn as to the quantities of sediment brought down by them. The sediments found in the samples that were obtained, are, however, separated from the waters carrying them, and are arranged in vials in the general exhibit referred to.

1880.

IRRIGATION.

REPORT.

INTRODUCTION.

THE PROBLEMS OF IRRIGATION.

To the Legislature of the State of California:

I am required to report concerning "the principles which ought to govern in the irrigation of lands."

The real object: To shape State policy.

In speaking of these principles I assume that those fundamental truths by which State policy should be shaped, are referred to; for a discussion of or any recommendation concerning the engineering "principles which should govern" in the location and building of irrigation works, or in the irrigation of lands, "strictly speaking, would be of little value to the State at this time, as compared to the facts and considerations which have a bearing on State policy." A comprehensive treatment of the subject opened up in the consideration of this matter would constitute a discussion of too great length for the limits of a readable official report. I propose, therefore, to consider only such points as have a direct bearing on the question as to what the State should do with respect to the irrigation interest, in order that a just estimate may be attached to such "practical recommendations" as are made at the closing of the subject.

SYSTEM IN IRRIGATION.

The irrigation experience of the world has conclusively proved that the general cultivation of the soil, where irrigation is essential to success, over wide areas of farming land varied in topographical disposition, composition of soil, and climatic exposure, is preëminently a pursuit which must be carried on in strict conformity with the established rules of a generally recognized system, under an administration at once wise, just, and potent, in order that a reasonably large percentage of the possible benefits to be derived therefrom, may be attained.

Obstacles to apportionment of waters.

Water, a most valuable element of prosperity, continually varying in amount, ever moving onward, wasting in many ways, constantly slipping from the grasp, though at best to be secured in quantity barely sufficient to supply the requirements of the many whose all depends upon their receipt of a share, is to be seized upon without detriment to the welfare of the members of those classes of

society, who, in a degree, are opposed to its diversion from the natural channels, and distributed to many different applicants, the interests of each of whom for the moment are antagonistic to those of all others having a claim upon the same common stock.

Apportionment of waters.

And this situation is complicated not only by the varied interests of the different claimants, as to area of property to be irrigated, and by the presence of soils each demanding more or less of the supply, according to their several compositions, to accomplish the same or parallel results, but by the cultivation of crops which call loudly for water at particular times and in varied quantities. And still more difficult is the administration of irrigation affairs made by the uncertainty, in most cases, as to the quantity of the water which there will be to distribute, and the time when it will present itself.

Thus, where long prevalent, irrigation has not only become in itself a real art for the practice of the husbandman, but has given rise to the development of novel legal machinery, and has so modified as almost to form anew the outlines of municipal and corporate organization.

All factors in the problem variable.

If the quantity of water to be disposed of for irrigation were known and invariable; or if the supply were amply sufficient for the watering of all dry lands within reach of the several sources; if all soils and all crops required the same, or any known amount of water to effect the irrigations, and any lands required the same amount of water in the first and each succeeding year; if all landholders were ready and willing to construct irrigation works, and all equally able to pay for them, according to the extent of their holdings of the soil; if all farmers were skilled irrigators, and there was a population at hand sufficient in number to make good use of the water; if lands of one particular class only were demanding water; or if there could be any final definition of what are to be regarded as irrigable lands, and what not irrigable, then would the problems of irrigation be simple and readily solved.

Some factors must be fixed.

There would be some fixed conditions—a given supply of water and a known demand. The State might then, by some general legislation, provide for the apportionment of the waters to the lands grouped into certain irrigation districts, and there would be thus created a good basis of credit upon which to procure means for the construction of the canals for each district; or, the State might safely undertake to carry out a system of works, and afterwards reimburse herself by taxation or otherwise from the properties benefited. Such is not the case, however. Every factor in the problems is variable in each instance and locality, and difficult of determination. But all system must have some basis for its foundation; either we must have fixed conditions, or a flexible system adjustable to conditions determined from time to time, otherwise there must be embarrassment or injustice.

The Main Questions.

Hence the main questions which first arise in the development of

regular system in irrigation as a process recognized and fostered by the laws of a land, are three in number, and may be stated briefly as follows:

First—To what lands are the waters to be allotted, in what measure to the several regions of country, and according to what scale as to priority of claim?

Second—Under what political organization and according to what legal system are the waters to be distributed amongst the consumers thereof?

Third—Upon what basis of security can the means be obtained to construct and put in operation the works necessary to accomplish the diversion and distribution of the waters?

The problems of irrigation.

These are properly the "problems of irrigation." All other questions connected with its development arise in the course of the consideration of one or the other of these points, met with at the very outset of the labor of systemization, or come up secondarily in the carrying out of that system, and consequently are of secondary importance. I shall endeavor to show that upon the settlement of the first two of these questions there will be a firm basis of credit in good irrigation property, when organized into districts under proper legislation, and that then the third problem will be solved.

The Present Policy of the State.

Thus far the policy of the State has been to leave the distribution of waters from the streams to the claimants thereof, and the settlement of disputes between the claimants to the Courts. The General Government might just as well throw open the public domain to appropriation, not have any Land Office, and not require any proof of claims, except when disputed in the Courts by some rival claimant. It must be perfectly apparent that under such a land policy there would be no basis of credit in lands. The country would be peopled with squatters, and there would be no defined rights, and no protection of those existing; neither would there be any limitation upon extent of appropriation by those who might have the means to obtain large holdings. It is just this policy which the State has pursued towards the irrigation interests—a *free-to-all* rule, which brings trouble to all.

The appropriation principle.

The three fundamental problems in irrigation never have been and cannot now be solved by a non-intervention policy on the part of the governing power of a land, except the result be to the benefit of a few at the expense of the many of its citizens.

The distribution of waters.

An element of wealth temporarily and at not very regular periods within reach, and then in quantities rarely sufficient for the necessities of all, is to be distributed amongst those to whom it is valuable. The demand for it is not constant, and it is most precious at the time of least supply. It cannot be stored to any great extent, and saved from a year of plenty to one of limited quantity, except at great expense and considerable wastage. It may be used at great dis-

advantage and detriment to the common welfare by the few who secure a priority of claim upon it, and in so doing they may profit the more by its use. Is it to be expected, under these circumstances, that the best or even good results are to be always obtained by withholding all restraint upon the appropriation and use of water?

Unity of action necessary.

To take advantage of a privilege to use of the common stock necessitates the command of capital. To employ this capital to advantage in the construction of works there must be a unit of demand of considerable proportions for the water. This unity of demand, and consequent action, is to be found only in the case of the rich landed proprietor, who may divert the water for his own use; in the case of associations or individuals who may enter upon the construction of works with the view of selling the water to small consumers, or in the case of an association of the consumers themselves, who coalesce for their common benefit.

The object in view.

I leave out of view altogether, for the present, the idea that works of irrigation may be constructed and maintained at the expense of government, and administered for the benefit of its citizens or subjects; and for the time being I assume it to be the desire that a system may be established in California whereunder the waters of the streams of the State may be apportioned to associations, in some form, of the consumers, and by them distributed to the individual irrigators, and thus even handed justice be dealt out to all, and prosperity insured to the greatest number.

The Principles which ought to Govern.

As I have said, there are many unknown quantities in this problem of irrigation. I am of the opinion that the irrigable lands of the State cannot at once be finally designated, nor can a system of irrigation works be wisely laid off for the watering thereof, except by a gradual process, to be developed from time to time, as the factors of the problem are made known by observation of the flow of the streams, the development of the State, and the practice of irrigation.

I submit that the "principles which ought to govern" in the shaping of State policy towards the irrigation interest, are embodied in the following paragraph, and in the succeeding chapters hereof I shall endeavor to further substantiate the position taken, and enter into details concerning a plan of action.

A State policy recommended.

This State should pursue a tentative policy towards the irrigation interest, and should occupy the position of a protector to all engaged in the use of water, a mediator between all claimants of water, a donor having a variable stock of a valuable commodity to distribute to those who will take it and use it economically—with the least possible waste and to the greatest possible advantage—keeping in view at all times that the demand must constantly increase, and that the greatest good is to be accomplished by distributing the supply to the greatest number of consumers who can comply with the other conditions of the gift.

WHAT ARE IRRIGABLE LANDS?

As an example of the difficulties met with at the outset in the establishment of system in irrigation, I call attention particularly to the wide range necessarily taken in answering the question: What are to be considered irrigable lands? The extent of lands to be regarded as irrigable must, of course, be proportioned to the quantity of the water supply to effect the irrigations.

Limitations in the Definition.

Besides this principal limitation, irrigable districts will be restricted in extent by the three following considerations:

First—The possibility of conducting water to the lands at reasonable expense.

Second—The possibility of distributing the water and applying it in irrigation at any reasonable expenditure of capital.

Third—The possibility of cultivating the soil by or with irrigation to advantage and profit.

A definition attempted.

It is here remembered that irrigation is, in certain respects, a progressive art, and that lands which might now be considered non-available—from some circumstances of their want of fertility under irrigation, or other cause inherent in themselves—will in a few years be in demand for cultivation, and stand ready to receive their quota of the water supply.

With this forecast of the future, it might be assumed, for present purposes, that *all lands upon which water may be brought, distributed, and used profitably in irrigation by some of the ordinary processes of the art practiced as an adjunct to extended general agricultural operations, may be ranked as irrigable,* and considered as such in the systemization of irrigation.

The Third Restriction dispensed with.

I have said that the lands to be regarded as irrigable will be limited by considerations of which that concerning the possibility of profitable cultivation is one.

Although there are considerable areas of country in the valleys of California, which, by reason of some circumstance of soil composition, probably *will not* be successfully cultivated by irrigation for many years to come, the extent of country which *cannot* be so cultivated from this cause alone, probably will prove in the distant future to be a small percentage of that upon which water can be conducted and distributed economically.

Why irrigation may not succeed.

The lack of skill on the part of the irrigators, the absence of proper knowledge of the working of soils, and the management and manipulation of crops, will constitute the chief causes of failure on these lands. Such failures are not to be altogether regarded as consequent upon some defect in the lands themselves, for they will occur to some extent in the cultivation of the best soils by irrigators of less experience.

A tentative policy.

Hence, as all of these lands can only be recognized beyond dispute when, after the lapse of time, much more is known of the behavior of California soils under irrigation than is at present, it may be deemed advisable to neglect this limitation upon the extent of lands to be regarded as irrigable, for purposes of preliminary systemization. And in the definition just given, all lands upon which water can be "brought and distributed," etc., might be classed as irrigable.

It will be seen, though, that circumstances which render some lands non-irrigable under the third restriction, make them equally so under the second; and it might be shown that the area of land upon which water may be distributed "by some of the ordinary processes," etc., but where soil is not fit for cultivation, is very small.

Thus we may be further justified in dispensing with the third restriction on lands to be regarded as irrigable, for preliminary purposes.

The First Restriction considered.

The first cause of limitation will be of more or less effect as the route from the source of water supply to the point or points of distribution presents great or small engineering difficulties.

In each case where water is to be diverted for the irrigation of a district, this is to be determined by special examination, and a route decided upon, which, in proportion to the irrigation to be accomplished by the works, is the cheapest in construction and maintenance, and which will bring the greatest area of favorably situated lands under irrigation at a reasonable expenditure of capital.

What expense is justified.

Here it may be remarked that the phrase "reasonable expenditure of capital," is employed to represent that limit of expense which the profits to be derived and the increased prospective value of property created will justify.

It is hardly within the range of possibility to determine this point in every case, over the whole field of possible irrigation, preliminarily, before some system is established. As will be seen in the succeeding portions of this report, the range of irrigable land, when bounded by this restriction, depends entirely upon the use to which the land is to be put. It will pay to go to greater expense to conduct waters to lands for some classes of cultivation than it will for others, and we cannot forecast the use to which all lands are to be put.

The Second Restriction considered.

Referring to the definition of irrigable lands, hereinbefore attempted, without the qualifying clause, "by some of the ordinary processes of the art practiced as an adjunct to extended general agricultural operations," it would be impossible to assign a limit to which lands are to be regarded as irrigable under this restriction.

For there are lands upon which water may be distributed in irrigation and "by some of the ordinary processes of the art," but which could not be thus irrigated by any such process when "practiced as an adjunct to extended general agricultural operations." Hence, we are led to an inquiry as to what are the "ordinary processes" of the art of irrigation, and upon what classes of lands may they be applied extensively, in general agriculture.

METHODS OF IRRIGATION.

Processes in irrigation.

A classification of the various processes of irrigation has been made by proceeding upon the idea that the leading features of the several plans of preparing the grounds to effect the distribution of the water, in themselves form sufficient distinguishing marks for the classes. In my opinion this method of classification fails, for the reason that the limits of the classes cannot be defined with any considerable degree of satisfaction, for one will merge imperceptibly into another.

Although this must be true in a degree of any system of classification, we may yet arrive at a more satisfactory result than that attained by the system alluded to, and by the following described channel.

Proposed classification of processes.

The manner in which the soil to be cultivated is called upon to receive the water to the greatest extent, should be taken as the distinguishing mark of a particular process of irrigation.

In the annexed classification of methods, the division to which any particular process belongs is determined from this characteristic, and thus we find four general methods of irrigation, as follows:

First—Irrigation by filtration from a sheet of water, downward through the surface layer of soil.

Second—Irrigation by lateral percolation, through the soil to be cultivated, from a supply adjacent, but not superimposed.

Third—Irrigation by absorption from a sub-surface supply.

Fourth—Irrigation by the absorption of drops of water sprinkled over the surface of the ground.

The methods of irrigation.

Artificial irrigation by the first general method is an imitation of nature's process of flooding lands by overflow from some stream or lake, and the processes ranked in this class may be, and generally are in California, called *flooding*.

And so that of the second class has for its pattern nature's manner of wetting river bottoms and meadow lands by percolation from the streams or natural ditches near by; and the term *ditching* may be applied as a general name to this method of irrigation.

Still again, the third general method of irrigation is a following out of nature's way of moistening the surface soil by the absorption of water brought through porous substrata from some distant source of supply.

While the sprinkling process, of course, is an imitation of irrigation consequent upon rainfall.

Manipulations in irrigation.

Although the foregoing embrace all the ordinary processes of the art of irrigation, in no case can all of the various plans, as adopted in practice, which would properly be ranked in any one of the four general classes, be applied with profit in "extended general agricultural operations."

Hence, it becomes necessary to define more explicitly the plans which may be so applied.

All methods of artificial irrigation necessitate the conduction of water from some source of supply, and its delivery at the various governing points in the topography of the lands to be watered, with a

greater or less degree of detail and precision, by or through the medium of conduits—whether closed pipes or open channels—of some sort.

There are, as may be supposed, processes of irrigation which in character partake to a degree, of more than one of the four general methods mentioned; but those which are more nearly types of the several classes will be spoken of herein at present.

By Downward Filtration—Flooding.

Flooding, as has been said, is a name applied to those processes of irrigation wherein the surface of the ground, together with the seeds, roots, or bottom, of the stalks, as the case may be, of the plants to be irrigated are covered with a sheet or layer of water.

By different plans classed under this heading, the application of the water may be in the form of a still pond, or that of a moving sheet or layer.

The Italian system.

If in motion, it may be a very shallow or thin layer, applied continuously for a considerable space of time to a growing crop, the stalks, leaves, and roots of which preserve the surface of the soil from abrasion, as in the case of the irrigation of the winter meadows or marcite fields upon the plains of Lombardy and other portions of Italy.

The English system.

Or, the water may be applied much more copiously, but for a comparatively brief space of time, as in the case of irrigation by the English bed work system.

The tropical system.

If the flooding be in the form of a standing sheet or pond of water, it may be applied as a rather deep covering, allowed to remain upon the ground until all be filtered through into the soil or evaporated into the atmosphere. The irrigation of sugar cane in Mexico and elsewhere, nearly all of the irrigation practiced in Egypt, and the watering of rice in some countries, are examples of this sub-class of the art.

The check system.

Or, partially as a still pond, and in a measure also as a moving sheet, the water may be applied successively to the divisions of a large tract; each such division—properly environed by ridges of soil to check the flow of the water—submerged for a brief period of time, the water being then drawn off to the next lower division, and so on down to the lowermost in the tract, whence the surplus is drained away.

This latter process is that which is most applicable in ordinary agricultural operations on a great scale. Generally speaking, large tracts of land may be prepared for irrigation by this method at less expenditure of capital than in any other thorough manner. The work of irrigation is more expeditious with the grounds thus arranged, under favorable circumstances, than by any other method. But it is applicable only upon lands of evenly formed surface and gentle slopes;

the soils of which do not readily wash while under water, or bake when exposed to the sun after watering. A considerable head or volume of supply, comparatively speaking, is necessary for advantageous irrigation by this method, and unless the irrigators are skillful and provident, and the grounds well prepared, it admits of great waste of water. Hence a greater expenditure of skilled labor in spreading the water is necessary, than by any other flooding process, at least. Furthermore, there are many crops in the cultivation of which this method of irrigation is not the most applicable.

By Lateral Percolation—Ditching.

In general terms, the practice of irrigation by lateral surface percolation has been called the "ditching" method. The actual location of the seed, root, or plant to be irrigated is not flooded, but receives its moisture by conduction through the interstices of the soil from the waters in a ditch or canal near at hand.

Garden irrigation—Leading ditches.

By some proceess ranked under this heading, the water is conducted in running streams, by numerous small ditches, between the rows of plants to be irrigated—as in the ordinary method of watering vegetables and small fruits—and this is done periodically, for a brief time on each occasion.

Garden irrigation—Still-water ditches.

In other cases of irrigating by lateral percolation, water is kept standing nearly all the time in much larger and deeper ditches, placed at greater intervals, whence it finds its way in the manner described to the soil where moisture is desired.

Field seepage system.

And again, in soils which admit of seepage or percolation in a high degree, the irrigation of large tracts is accomplished by conducting the water in canals or ditches still greater in dimensions along the higher ridges of the undulating plains, whence it percolates laterally down the slopes, moistening the surface and subsoils without the distributing agency of ditches or the process of flooding.

Advantages of the ditching method.

As may be supposed, this method of irrigation is attended with great advantages, both as to economy in the preparation of lands and in the expenditure of labor in the work of applying the water. But, under many circumstances, it may be just the reverse of economical in the consumption of waters or in the matter of time necessary to accomplish the desired irrigations.

Seepage soils.

The soils upon which irrigation can be accomplished by this method are of comparatively rare occurrence, and in many instances the cultivation and continued wetting of them greatly modifies or totally destroys that property which facilitates the process of percolation, and thus necessitates the adoption of irrigation by flooding in the end.

By Absorption—Sub-surface Irrigation.

Underground irrigation scarcely admits of any subdivision in the matter of its application, at least which would show a greater or less degree of fitness for use in general agricultural operations. It is to be ranked as one of the ordinary processes of the art of irrigation, but has not yet been adopted as "an adjunct to extended general agricultural operations," though the time may come when it should be ranked with some others in this respect.

By Surface Absorption.

Sprinkling of course, except as nature bestows the rain, is not to be regarded as a method of irrigation applicable in general agriculture; and it is not further considered in this report.

The Application of this Review.

From a glance at some of the characteristic features of the ordinary methods of irrigation, we see that under various circumstances the art may be extensively applied in general agriculture, by some one of the flooding, ditching, or sub-surface methods, up to a point where the expense of preparing the lands to receive the water will be so great as to preclude the use of the particular process in each case proposed.

Now this expense augments more rapidly with the increase in slope and the inequality in the ground's surface than with any other circumstances which admit of gradation (I assume now, of course, that land to be irrigated at all must have soil which will yield to the plow.)

Comparative cost by different methods.

Of the three general methods now considered, sub-irrigation, probably, may be practiced on land of the steepest inclination and most uneven surface, if the soil is favorable to the absorption and percolation of the water; what has been called the ditching method will come next in this scale; while flooding the ground can only be practiced as a process in extended general farming, upon lands of comparatively even surface and small degree of slope or inclination.

Sub-irrigation upon lands of nearly level surface must ever be the most expensive method, so far as first cost of preparation is concerned at least.

As between ditching and flooding processes, the same is true of the former as just said of sub-irrigation when we were considering all of the three.

And yet it may be shown as a general rule, when, by reasons of the increased slope or ruggedness of surface of lands, the cost of preparing them for irrigation by some process of flooding the surface becomes so great that they can not be regarded as irrigable for purposes of extensive farming, the cost of preparing to distribute the water by either of the other two methods will be still greater. Local exceptions to this rule, of small range, may occur where the soil admits in a high degree of irrigation by lateral surface percolation; but the rule will hold good in general application.

CONCLUSIONS.

Hence, in outlining any district where irrigation is a necessary adjunct in general agriculture, *at the limit where the preparation of the ground for irrigation by flooding would necessitate so much labor as to debar its adoption as "an adjunct to extended general agricultural operations," we might draw the boundary line of what should be considered irrigable land in the projection of system in irrigation on the plains in California.*

Gradations of cultivation.

But there are lands now under irrigation, and there will be districts demanding irrigation, to which this rule cannot be applied, because of the greater value of crops cultivated, and consequent greater expenditure justified. And there will be lands included in other irrigation districts which will necessarily be held exempt from this rule; but it is the nearest approach to a general rule which can be framed.

What it is necessary to know.

From what has been said, it will be seen that a knowledge of the physical characteristics of the lands proposed to be watered—their topographical configuration, soil and subsoil composition—is essential in the determination of the point as to whether or not they are to be regarded as irrigable. But irrigation is not a *necessary* adjunct to general agriculture in all quarters where it is desirable to have water at command for some crops.

Varied character of irrigation.

Thus, while indispensable in some portions of the State, irrigation will be a partial necessity in others, as will be shown in the next chapter, if California is ever to attain that proud position as a thickly populated, prosperous, and powerful commonwealth, which has been so frequently predicted as her destiny. The extent to which lands will be irrigated, where irrigation is not a necessity upon all, depends upon the character of cultivation undertaken. This will change with the lapse of time, and its measure cannot be foretold.

Time necessary to solve the problems.

How, then, is the question to be answered as to *what are irrigable lands*, and what are not, in this State? The reply can only come with the lapse of time. We may, after the preliminary examination already begun by this Department is completed, give an answer sufficiently accurate and in detail upon which to base some legislation for the systemization of irrigation under general State regulations; but the question never can be fully answered until the end of time.

CHAPTER I.

THE NECESSITY FOR IRRIGATION, AND THE IRRIGATION REGIONS OF CALIFORNIA.

The Necessity for Irrigation.

Irrigation throughout California.

It would seem that the necessity of irrigation over an immense area of the most desirable agricultural lands in this State, is too generally recognized to admit of its being noticed at any length in opening this report; that the report itself has been authorized were ample proof of that fact, if any were wanting.

If this subject were one for the present only; if local necessities, now so glaringly apparent, were all that must be considered, it might be well to leave unsaid much which will find place herein. But it will be seen that even to-day the subject is one of broader range than generally recognized; it will be seen that it is one which will grow rapidly with each year of progress, and, I believe, it should be appreciated at once, that irrigation will in the not very distant future, be extensively practiced and regarded as necessary in almost every county in the State.

Irrigation not local only.

The law under which this report is made provides that the State Engineer "shall ascertain the position and acreage of all lands in the valleys of the State which are now or may in the future be in need of irrigation," thus recognizing the progressive outlook of the subject, and placing its consideration upon the basis which I have spoken of, so far as probability of future expansion is concerned. But in speaking only of the "lands in the valleys," and the "irrigation of the plains"—as it does in another place—the very important fact has been overlooked that irrigation, even at this time of its infancy on this Coast, is not confined to valleys and plains, but has been put in operation upon almost every class of rolling, foothill, and mountain land where the soil is suited for cultivation at all, and that it will demand recognition on the part of the State wherever practiced within her borders. I hope it will be seen that, though this has been largely a local interest, the time is rapidly coming when it will be a leading issue in nearly every locality in California, and that thus the whole State is deeply interested in placing it upon a proper footing.

Irrigation of winter crops.

The failure of the staple crops from the effect of winter's drouth, when cultivated without irrigation in certain localities, however widespread such disasters really are, does not indicate the limit where irrigation is necessary, in order that this State may become populated measureably with its older sisters. We have not here the summer showers which render a diversified agriculture possible, yet it cannot

be expected that the products of the broad plains even can long continue to be wheat and barley only. In the great central valley of the State, for instance, south of the Merced River, it may be said that profitable cultivation without irrigation is practically impossible except on limited spots along the foothills of the Sierra, and about Merced (where the heavier soils admit of summer fallowing to advantage), or on the bottom lands of streams receiving moisture by percolation from below.

Irrigation of summer crops.

North of that line it is still a partial necessity, and as agricultural products become more diversified the want will increase. Summer crops, wherever grown, from the southern portion of the San Joaquin to the extreme northern part of the Sacramento Valley, equally require irrigation; and should the almost universal wheat farming ever give place to the agriculture common to the Eastern and Southern States, where rain falls throughout the year, irrigation must be the means of its accomplishment, and be generally practiced throughout the country wherever water may be made to flow through the fields with profit and success. We may look forward to the time, then, when the plains of the Sacramento Valley, where the soils are at all favorable, will be under irrigation, as well as those of the San Joaquin. The lands will be divided into smaller tracts, and, generally, each farmer will have from 10 to 30 per cent. of his property under irrigation, at least for summer crops, while the remaining area may be devoted to the present system of growing grain, for many years more.

RAINFALL IN IRRIGATION REGIONS.

The rainfall here is less in amount than in other countries where irrigation is prevalent from necessity; and, furthermore, it is not so evenly distributed throughout the year, and does not occur at all when moisture is necessary for the growth of most crops. The following tabular exhibit is instructive in this connection:

TABLE

Showing a comparison between the average monthly rainfall in the several great valleys of California with that over some of the irrigation regions of other countries.

Months.	* Lombardy, Italy. Average of ten years' observations—inches	* Piedmont, Italy. Average of ten years' observations—inches	† Bouches du Rhone, France. Average of a series of years' observations—inches	‡ Valencia, Spain. Average of four years' observations—inches	† Valladolid, Spain. Average of four years' observations—inches	† Grenada, Spain. Average of four years' observations—inches	§ Madras, India. Average of seventeen years' observations—inches	‖ San Antonio, Texas. Average of seven years' observations—inches	Sacramento Valley. See next table—inches	San Joaquin Valley. See next table—inches	Los Angeles and San Bernardino Valleys—inches
January	¶	¶	1.7	0.95	0.57	2.40	1.17	1.52	3.70	2.10	-----
February	¶	¶	1.7	1.75	1.76	2.26	0.37	4.18	3.00	1.15	-----
March	2.30	2.84	2.1	1.56	1.53	2.36	0.44	2.30	2.50	1.40	-----
April	3.10	4.14	0.9	0.29	0.86	3.69	0.71	2.23	1.40	0.64	-----
May	3.80	6.33	2.2	2.23	3.06	5.90	2.28	2.71	0.76	0.00	-----
June	3.10	3.71	1.1	0.82	2.36	3.37	2.26	3.37	1.15	0.00	-----
July	2.80	3.37	0.5	1.26	0.31	1.29	3.60	1.72	0.03	0.00	-----
August	3.20	4.80	1.6	0.67	0.68	0.11	4.00	3.14	0.00	0.00	-----
September	3.40	3.37	2.8	0.46	0.18	0.08	4.20	4.37	0.06	0.01	-----
October	¶	¶	3.3	2.04	3.36	1.45	13.63	1.40	0.70	0.40	-----
November	¶	¶	2.7	2.64	4.63	7.11	10.74	3.26	2.00	1.60	-----
December	¶	¶	1.5	1.21	1.56	3.40	6.10	2.73	4.20	3.20	-----
Annual averages	------	------	22.1	15.88	20.86	33.42	49.50	32.93	19.50	10.50	15.[illegible]

Notes to the foregoing Table.

* From Italian Irrigation—R. Baird Smith, F. G. S.
† From Professional Paper—Allan Wilson, Mem. Inst. C. E.
‡ From Professional Paper—George Higgin, Mem. Inst. C. E.
§ From Manual of Hydrology—Nath. Beardmore, Mem. Inst. C. E.
‖ From Smithsonian Contributions—C. A. Schott, Mem. A. Phil. Soc.
¶ Monthly averages not available.

TABLE

Showing a comparison between the average quarterly rainfall in the great valleys in California with that over some of the irrigation regions of other countries.

Region.	Winter rainfall—inches	Spring rainfall—inches	Summer rainfall—inches	Autumn rainfall—inches	Average yearly rainfall—inches
Lombardy, Italy	8.0	9.3	9.2	11.8	38.3
Piedmont, Italy		13.3	11.9		38.5
Bouches du Rhone, France	4.9	5.2	3.2	8.8	22.1
Valencia, Spain	3.9	4.1	2.8	5.1	15.8
Valladolid, Spain	3.9	5.4	3.4	8.2	20.9
Grenada, Spain	8.1	11.9	4.8	8.6	33.4
Madras, India	7.6	3.4	9.9	28.6	49.5
San Antonio, Texas	8.4	7.2	8.3	9.0	32.9
Sacramento Valley	10.9	4.7	1.2	2.7	19.5
San Joaquin Valley	6.4	2.0	0.0	2.1	10.5
Los Angeles and San Bernardino Valleys	10.5	2.5	0.0	2.0	15.0

In Italy, France, Spain, India, etc.

The Valley of the Po.

Lombardy and Piedmont constitute the greater portion of the famous irrigation region of the Valley of the Po, in Italy. In these districts water for irrigation is in greatest demand during the months of May, June, July, and August, yet the average aggregate fall of rain for these months is found to be in Lombardy 12.9 inches, and in Piedmont 18.21 inches. During the seven months, commencing with March, which are regarded as the irrigation season, in Lombardy there are, on an average, 24 rainy days, with an aggregate of 22 inches of rainfall; in Piedmont there are, on an average, 71 rainy days, with an aggregate amount of 28.5 inches of rainfall. The total rainfall for all of Lombardy may be placed at 36 inches on the average, and in Piedmont at 37, but in special localities it is greater, as, for instance, it has been found to be in Lodi 38.3 inches, distributed as to time in very much the same order as that given in the table.

The delta of the Rhone.

And again, in the Department of the Bouches du Rhone, in the South of France—a great irrigation region—rainfall is distributed throughout the year, and there are about nine inches received during the six months of summer, commencing with the first of April, which are regarded as the irrigation months, and during which a great variety of crops are cultivated.

The South of Spain.

Valencia, Valladolid, and Granada, are regions where irrigation is extensively practiced in Spain; and, as shown by the table, the conditions of these are also such as prove the necessity for irrigation, where even more rain falls, and under circumstances more favorable than those which obtain in California.

The seven months, commencing with March, are there regarded as

the full irrigation season, and it will be seen that the average rainfall during those months is for Valencia, 7.29 inches; for Valladolid, 8.98 inches; and for Granada, 16.80 inches.

The delta districts of India.

The irrigation regions of the Godavery, the Kistnah, and the Cauvery Rivers in India—amongst the most important of that country—are on the coast, in the neighborhood of Madras, where the table of rainfall shows the same general fact—that artificial irrigation is a necessity where there is much more moisture precipitated upon the land than in any of the valleys of California, for there we find (as per the table) 49.5 inches of rainfall well distributed through the year, whilst the Sacramento Valley only receives 19.5, and the San Joaquin Valley 10.5 inches on the average, and this with four to seven months of, practically, no rain at all. It is worthy of remark here that the irrigation in the districts of India just referred to, is the most successful and remunerative in that empire, though there are other places where the necessity for it is greater, the works provided are better, and the water supply sufficient.

On the upper Loire.

The plain of the Forez, upon the upper portion of the river Loire, in France, until quite recently, was a pestilential marsh. It is now in a great degree drained and brought under irrigation, notwithstanding the fact that the rainfall received by it is upwards of 34 inches per annum.

The Valley of the San Antonio.

Irrigation is extensively practiced near San Antonio, in Texas, yet the table shows that there, also, the rainfall is much greater than upon the valleys of California; and it is remarkably well distributed too—being for the spring months 7.24 inches, the summer months 8.23, the autumn months 9.03 inches, and for the winter months 8.43 inches.

Upon the Great Central Valley of California.

The Sacramento Valley.

In the Sacramento Valley on the eastern plain, the average annual rainfall may be placed at 19.5 inches—about that received at Marysville. At Sacramento, near the lower end of the valley, the average for the past twenty-nine years has been about eighteen inches, and at Red Bluff, near the upper end of the valley, the average for a much shorter period, approximates 21.5 inches. Upon the west side of this valley, from experience of the farmers, it is safe to say that the rainfall is probably two to three inches less than on the east, though the records available for the past two or three years do not show this conclusively. Thus the average of (19.5) the east side is certainly taken large enough, if not too large, for the entire valley.

The San Joaquin Valley.

The lower portion of the great valley receives a much less fall of rain at the extreme southern end; the average precipitation is only about 6 to 6.5 inches, and this includes years of flood. At Stockton the upper extremity of the valley, twenty-eight years of observation

have shown an average of about 16.8 inches, and intermediate points of observation have furnished partial data, which justify the statement that the average rainfall on the east side of the valley is about 10.5 to 11 inches. As in the case with the Sacramento, the precipitation is known to be less on the west side (indeed this is more marked in the San Joaquin), so that 10.5 inches of rain annually, certainly represents a full average for the entire valley.

The following table shows the data for these statements, as well as for others which follow:

TABLE

Showing the average monthly rainfall on the east side of the great central valley of California.

Months.	Sacramento Valley.				San Joaquin Valley.				
	Red Bluff	Marysville—Yearly average as observed and estimated	Sacramento—Average of twenty-nine years' observation	Average for the valley	Stockton—Average of twenty-eight years' observation	Merced—Yearly average as observed and estimated	Visalia and Bakersfield	Average for the valley	Average for the great valley
September		0.06	.063		.016	0.00	0.00		
October		0.70	.621		.475	0.40	0.00		
November		2.05	1.964		1.892	1.60			
December		4.30	4.176		4.354	3.20			
January		3.80	3.596		3.332	2.10			
February		3.20	2.863		2.583	1.15			
March		2.70	2.431		2.405	1.40			
April		1.60	1.390		1.158	0.64	0.00		
May		0.86	.731		.521	0.00	0.00		
June		0.20	.121		.057	0.00	0.00		
July		.03	.028		.017	0.00	0.00		
August		.03	.003		0.003	0.00	0.00		
Yearly average	21.5	19.50	17.987	19.5	16.813	10.5	6.5	10.5	15.0

The west side of the valley.

As before remarked, the above exhibit is for the east side of the valley only, there being no statistics for the west side, extending over a period of time long enough or taken at a sufficient number of points, to afford a fair average result in figures; but it is known that in the Sacramento, as well as in the San Joaquin Valley, the amount of precipitation west of the low lands is much less than on the east side; so much so, that there have been several movements towards inaugurating irrigation there on a large scale (as will hereafter be explained), and there is now a considerable area of land annually watered artificially on that side of the valley; whereas, on the eastern plain, there is not any to an extent worthy of note.

Result of the comparisons.

With the showing made in these tables for the Sacramento (which is indeed the rainy valley of the State), compared with the statistics

of rainfall upon a number of those great regions in Italy, France, Spain, India, etc., where irrigation is found to be a necessity, it can hardly be denied that pretty much all of California is to be regarded as an irrigation region. Indeed, while our most moist valleys are not up to the standard of many great irrigation regions in the matter of rainfall, there is hardly any country in the world where the necessity for artificial watering exists to so great an extent as it does here in the southern half of the great central and in the great southern valleys of the State.

Countries of minimum rainfall.

Upon the northern coast of Africa, in Algeria, where the French have of late years reëstablished irrigation, and in Egypt, we find regions where irrigation has been attempted under conditions as little favorable in the matter of natural rainfall as exist in the southern part of the San Joaquin or Tulare and Kern Valleys. But, indeed, these are not much, if any, more unfavorable than those here presented; for we are to judge of the necessity for irrigation, not so much by the average annual rainfall, as by the periods of its distribution in the seasons and the recurrence of years of drouth. The arrangement of conditions in this regard may make a country nearly uninhabitable without irrigation, though the average rainfall through a period of years be not so very small.

Drouth in California.

Thus there have been seasons of only eight to ten inches of rainfal in the Sacramento Valley, and four to six inches in the San Joaquin with a large area rainless at the southern end of the great plain And, generally, such years have been preceded by two or three year of light rainfall, so that crops have failed from Red Bluff to Calienté except at some limited favored localities. These facts should b remembered, for such a succession of dry years may, and probabl will, come in the near future, and it is by these we are to gauge th importance of this subject of irrigation and the scope of its bearings

Irrigation of Swamp Lands.

There is still another point to be considered in this matter of th future of irrigation in California. The low lands of the great valley those for which we now are planning to prevent inundation, wil when reclaimed require irrigation and demand a portion of the wate supply.

It is no sufficient denial of this assertion, to say that very much c such land as now reclaimed is yet too wet for cultivation. In th first place, this latter truth only applies to a class of the lands whic constitute a minority in the 2,700 square miles between Red Blu and Bakersfield, which are naturally subject to overflow; and in th next place, this condition will gradually change so that irrigation wi be desirable, if not necessary, on all, for some classes of cultivation.

Swamp lands irrigated in Egypt.

The entire irrigated region of Egypt is in a position to be swam land—below the level of the floods in the Nile and protected b levees from uncontrolled inundation. Yet the rainfall there

scarcely less than that upon the great regions of overflow in Tulare and Kern Counties in some series of years.

Swamp lands irrigated in Italy.

Large portions of the valley of the Po are as much below the flood elevations in that river as the basins of the Sacramento are below the level of its floods, and yet they are to a great extent irrigated, and in some localities more completely brought under irrigation than the higher plains, and this too, it must be remembered, where there is much more rain than on California's wettest plains.

Swamp lands irrigated in France.

And again, the great plain of the Forez, in France, comprising 240 square miles of territory, until recently subject to almost complete inundation, has been drained and reclaimed with the view of irrigating it.

Swamp lands irrigated in Majorca.

Upon the great swamp of the Albufera, in the Island of Majorca, reclamation and irrigation have also gone hand in hand; and so instances might be cited, almost without number, which would illustrate the proposition that we must look forward, even now, to the irrigation of lands for which the present effort is to reclaim them from uncontrolled inundation.

Why swamp lands are irrigated.

If it be asked why low and, in some instances, moist lands are irrigated, the reply is, because generally the soils of such lands are most favorable for cultivation under irrigation, and crops of greater value can be produced upon them by the aid of water, artificially applied, than elsewhere or otherwise, and sound business considerations will bring about what may seem strange to California ears now.

Irrigation not a local question.

There is a practical application of these comparisons which it is well should be made at this time. It must be apparent that if the agricultural lands of California are ever to support a population of 100 to 150 people to the square mile, it will only be accomplished by irrigation. Hence, the problems of irrigation are not local questions, but, of a right, affect every quarter of the State where there are good lands and water to irrigate them with. It will be noticed that this is a point foreshadowed in the introduction to this paper.

THE IRRIGATION REGIONS OF CALIFORNIA.

There are, of course, certain regions, embracing particularly fertile lands, where the need of irrigation is much more felt than in any other quarters of California where the water supply is nearly adequate to its satisfaction, and the problems are there to be studied first.

Thus the southern half of the great central valley of the State, embracing the San Joaquin, Tulare, and Kern Valleys (referred to hereafter collectively as the San Joaquin Valley), and the San Bernardino and Los Angeles County valleys and plains, which slope to the sea, afford the greatest irrigation fields of the present and the

future, and these quarters have been the scene of special investigations.

Before passing to the results of the studies made, I give a brief description of these regions, their irrigable lands, and the practice of irrigation thereon, as well as some notice of other quarters where irrigation is needed and practiced.

THE SAN JOAQUIN VALLEY.

That portion of the great interior basin of California, which has received the designation of the San Joaquin Valley—including Tulare and Kern Valleys—lies between the Sierra Nevada and Coast Range Mountains, which, coming together as the Tejon and Tehatchape Mountains, about the 35th degree of north latitude, form its southernmost limit. The general direction of this valley is nearly parallel with the trend of the coast—northwest and southeast—from which its central axis is from 75 to 100 miles distant. Its northern boundary is undefined, but the dividing line between it and the Sacramento Valley has been taken, for the purpose of this report, at the Cosumnes River, the northernmost stream draining into the San Joaquin. Its greatest length is 260 miles, and in width it varies from 30 to 70 miles. Its total area is 11,290 square miles.

The plains and basins.

The valley consists of two plains of unequal width, extending from the foothills of the mountains and meeting in a trough, not midway, but considerably west of the center line of the great depression. This trough, running from one end of the valley to the other, has a general inclination in a northwesterly direction towards the outlet for all drainage waters of the great basin, Suisun Bay. Its slope is not uniform, but flattens out at intervals where lakes and marshes exist, as the streams flowing in on either side have banked up the silt and detritus washed from the mountains at special points for ages past. In this manner Kern River, sweeping down enormous volumes of decomposed granite, has spread out a broad barrier across the valley, inclosing a basin above it for the reception of the waters forming Kern and Buena Vista Lakes, at the southern extremity of the trough; and Kings River, carrying its load of sand and silt to the lowest part of the valley, has raised a dam across the depression and completed the shallow basin where now exists Tulare Lake, one of the greatest sheets of fresh water in California.

The trough of the valley.

It is probable that this trough once held the bed of a continuous stream from Kern River, extending throughout the length of the valley, and receiving the tributaries flowing in on either hand. As it is, the depression serves as the drainage way for all the valley, however impeded may be its course. From Kern and Buena Vista Lakes, which occupy the same level in the lowest depression of the southern end, and are at an elevation of about 293 feet above low tide, it slopes at the rate of about 2 feet per mile for 42 miles, to Tulare Lake, whose elevation is 198 to 210 feet, according to the stage of its waters. Thence to the mouth of Fresno Slough at the great bend of the San Joaquin, 55 miles from the lake, the slope is 0.86 feet per mile. The total fall from this point to the mouth of the San Joaquin River, a distance

of 120 miles, is 165 feet, the slope per mile as a general rule diminishing gradually to tide level.

The lakes and swamp lands.

Kern and Buena Vista Lakes occupy an area of 13 and 25 square miles, respectively, of this central trough, while Tulare Lake carries a surface of 575 to 850 square miles—varying with the stage of water. Of swamp lands, either partially reclaimed or subject to periodical inundation, the basin contains in the vicinity of Kern and Buena Vista Lakes 87 square miles; between Buena Vista and Tulare Lakes, 160 square miles; west and north of Tulare Lake, 158 square miles; along San Joaquin River, between Fresno Slough and the mouth of the Stanislaus River, 82 square miles; and in the delta of the San Joaquin and Mokelumne Rivers, 488 square miles; an aggregate area of 975 square miles.

The San Joaquin River.

The San Joaquin River, which, in its lower course, is the central drainage line of the great basin, heads in the Sierra Nevada Mountains, and, flowing in a southwesterly direction, enters the plains but little south of the center of the valley which generally takes its name, though the country south of it is frequently designated locally as the Tulare and the Kern Valleys. Pursuing a course across the great basin plain in the same general direction until the trough is reached, it makes a great bend northward, receiving numerous accessions to its volume, which rapidly convert it from a comparatively small stream to a navigable river. At the great bend it receives the waters which, overflowing successively from Kern, Buena Vista, and Tulare Lakes, in time of excessive flood, join it through the Fresno Swamp drained by the Fresno Slough.

The tributary rivers—East side.

The streams immediately tributary to the San Joaquin and flowing from the Sierra Nevada, with few exceptions, lie in deep channels for many miles out from the mountains, and do not approach the level of the plain until shortly before reaching the trough, where their waters turn northward. On the contrary, the streams which enter the valley from the Sierras south of the San Joaquin are in remarkably shallow channels at the points of leaving the mountains, but generally have cut deeper ways through the plains proper, and, as in the case of those further north, come near to the surface again upon approaching the trough.

Mountain watersheds—East side.

The following are the principal streams entering the San Joaquin Valley as above described, on the east side, named in their order from north to south, with the area of watershed drained by each:

Designation.	Drainage area.
Cosumnes River	589 square miles
Dry Creek	208 square miles
Mokelumne River	573 square miles
Calaveras River	390 square miles
Stanislaus River	971 square miles
Tuolumne River	1,514 square miles
Merced River	1,072 square miles
Bear Creek	153 square miles
Mariposa Creek	96 square miles
Chowchilla Creek	303 square miles
Fresno Creek	258 square miles
San Joaquin River	1,630 square miles
Kings River	1,853 square miles
Kaweah River	608 square miles
Tule River	446 square miles
Deer Creek	130 square miles
White River	96 square miles
Posa Creek	278 square miles
Kern River	2,382 square mile
Calienté Creek	461 square mile
Sundry small streams	2,138 square mile
Total area of mountain and hill drainage	16,149 square mile

Remarks on the table.

The names of streams designated in italics are perennial in thei flow. The lofty mountains in which they rise store away the pr cipitation of the annual rainy season in the form of snow, whic melts slowly throughout the summer and never wholly disappear giving down a steady and unfailing supply, its greatest volume gauged to that season when most required for watering the thirst plains below, namely, in the late spring and early summer month The others are intermittent in flow, and do not furnish a continuou supply for purposes of irrigation.

The tributary streams—West side.

The streams on the western side of the basin, discharging from th Coast Range, are all of the most intermittent character. The moun ain sides are steep and almost devoid of forests, which might ho back the waters of precipitation. The land is consequently rapid drained, and the streams are in flood for but a short period after ea rain. They descend upon the plains in channels, which in mo instances are lost before reaching the central trough, the waters many of them spreading at will over the high sloping valley lan adjacent to the mountains, and seldom reach the river. As sourc of supply for irrigation they are therefore unreliable, and at be available for but a limited area in the vicinity of their several poir of entrance upon the valley.

Mountain watersheds—West side.

Following this, the principal creeks on the west side of the vall are named in their order going southward:

Designation.	Drainage area.
Marsh's Creek	82 sq. miles.
Corral Hollow Creek	69 sq. miles.
Hospital Creek	46 sq. miles.
Arroyo de los Piedras	15 sq. miles.
Arroyo del Puerta	78 sq. miles.
Orestimba Creek	124 sq. miles.
Las Garzas Creek	39 sq. miles.
Quinto Creek	41 sq. miles.
Romero Creek	31 sq. miles.
San Luis Creek	74 sq. miles.
Los Baños Creek	115 sq. miles.
Saucelito Creek	78 sq. miles.
Little Panoche Creek	147 sq. miles.
Big Panoche Creek	285 sq. miles.
Cantua Cañon Creek	130 sq. miles.
Los Gatos Creek	480 sq. miles.
Sundry small streams	1,628 sq. miles.
Total area of mountain and hill drainage from the west	3,462 sq. miles.

Mountain watersheds—south side.

At the head of the valley the following streams drain into it from the Tejon or San Emidio Mountains:

Designation.	Drainage area.
San Emidio	72 sq. miles.
Arroyo Plata	530 sq. miles.
Tacuya	
Cañada de las Uvas	
Tejon	
Sundry small streams	
Total area of mountain and hill drainage from the south	602 sq. miles.

Total drainage area.

To sum up: The waters from an aggregate area of 20,213 square miles of mountain and foothill lands enter the valley from all sides. The entire extent of the basin of the San Joaquin—mountain, hill, plain, swamp, and water surface—is found to be 31,503 square miles, of which 36 per cent. is in the valley proper.

IRRIGABLE LANDS OF THE GREAT VALLEY.

The irrigable lands.

The lands requiring irrigation and specially suited to cultivation by it are here referred to as *irrigable* lands. And it is assumed, as an approximation to the general truth, that all of the country west of the trough of the valley and all east of it and south of the Mokelumne River are of this class, where their soil composition and topographical shape are favorable and where water can be led upon them from any source of supply adjacent to the plains.

We are now led to a consideration of the extent of this irrigable area, in the natural subdivisions of the territory described.

East Side of the San Joaquin.

Cosumnes River to the Tejon Mountains.

Beginning on the east side of the San Joaquin Valley, the *dry plain lands* may be grouped, according to their natural divisions, as follows:

Designation.	Total area of dry plain land, sq. miles	Probable area of land suited to irrigation, sq. miles
Between Cosumnes River and Dry Creek	260	*
Between Dry Creek and Mokelumne River	121	*
Between Mokelumne River and Calaveras River	366	*
Between Calaveras River and Littlejohn Creek	170	*
Between Littlejohn Creek and Stanislaus River	321	*
Between Stanislaus River and Tuolumne River	267	203
Between Tuolumne River and Merced River	506	258
Between Merced River and Bear Creek	268	187
Between Bear Creek and Chowchilla River	411	258
Between Chowchilla River and Fresno River	345	227
Between Fresno River and San Joaquin River	402	258
Between San Joaquin River and Kings River	1,164	640
Between Kings River and Kaweah River	559	359
Between Kaweah River and Tule River	579	289
Between Tule River and Sixth Standard South	423	242
Between Sixth Standard South and Kern River	831	450
Below Kern River	694	290
Total area	7,687	----------

No examination has been made of the lands northward from the Stanislaus.

The sources of water supply.

The perennial streams heretofore designated are of course the main dependence of these lands for irrigation supply, supplemented to some extent by the numerous smaller creeks, whose discharge, though intermittent and variable, is of great volume at certain seasons of the year, and may be made of much utility, no doubt, in some instances, by the aid of storage reservoirs.

West Side of the San Joaquin Valley.

The irrigable lands.

The total area of dry plain land on the west side of the central trough of the Valley of San Joaquin is about 2,689 square miles. All south of Tulare Lake and a large portion north of the lake, on this west side of the great basin, may be classified as non-irrigable land, not only on account of the absence of a sufficient water supply, but by reason of the general unfitness of the soil for cultivation by irrigation.

The sources of water supply.

The sources of supply for irrigation are Tulare Lake (used as a reservoir to receive the drainage of all irrigated lands south of Kings River, as well as the surplus of the streams from which water for irrigation is now diverted), the San Joaquin River, and the small streams of the Coast Range.

Areas of irrigable lands.

The total area of dry plain land to be irrigated, supposing for the time that Tulare Lake or Kings River is a good source of supply for this section, is about 718 square miles or 460,000 acres. But, supposing that the San Joaquin River is the only available source besides the intermittent creeks, the area would be reduced to 240.39 miles, or 153,000 acres, together with 133,000 acres additional, but naturally subject to everflow during seasons of ordinary high flood in the valley.

Irrigable Lands in the Sacramento Valley.

Area of irrigable lands.

The region on the west side of the Sacramento Valley which may be spoken of as irrigable, is about 1,220 square miles, or 780,000 acres in area. The total area of the plain between the river and the foothills is about 2,000,000 acres. A large portion of this territory spoken of in Part II of this report as the Colusa and Yolo Basins, is naturally subject to overflow, and another part is broken ground of too uneven surface for economical general irrigation, and lying too high to be watered from the main sources of supply.

Sources of water supply.

The water for this irrigation must come from the Sacramento River at or near Red Bluff, and from the creeks which drain the Coast Range, and enter upon the irrigable plain at intervals along its western side.

Stony, Cache, and Putah Creeks are of sufficient magnitude to materially assist in supplying water for the great plain, but the other creeks, of which there are 15 or 16 in all, are insignificant in volume of discharge, except during seasons of heavy rainfall, when irrigation is not needed. The Sacramento River must be looked to as the main source of supply for any sustained and extended irrigation of the lands west of it and north of Cache Creek.

The Bryan survey.

A line was surveyed in 1866 for a canal to effect this irrigation. It commenced just below the mouth of Red Bank Creek, near Red Bluff, and extended to the Montezuma Hills, a distance by the grade of 190 miles. Below this proposed canal line, and above the line of overflow, the main irrigable belt is situated. It is about 140 miles in length through its axis, and in no place exceeds 16 miles in width. Above the line of the proposed canal there are regions limited in area which may be irrigated from the creeks—as for instance, Capay Valley, 18 miles in length by one or two miles in width—irrigable from Cache Creek, and Berryessa Valley, irrigable from Putah Creek if waters are stored for the purpose. The irrigation investigations of this Department have not extended to this region, except in the matter of a short reconnoissance of the scene of irrigation from Cache Creek, an account of which will be found in an Appendix.

Other Irrigation Regions.

Other sections where irrigation is a necessity in California, will be spoken of in the next chapter, in connection with a notice of the practice of irrigation in each quarter.

CHAPTER II.

THE WORKS, PRACTICE, AND RESULTS OF IRRIGATION IN CALIFORNIA.

IRRIGATION IN SAN BERNARDINO AND LOS ANGELES COUNTIES.

The Irrigation Region.

The irrigation region of Los Angeles and San Bernardino Counties is chiefly confined to two large valleys, one of which lies at the base of the Sierra Madre and San Bernardino Mountains, which form its northern and eastern boundary. This upper valley is limited on the south and west by a chain of hills, which has been designated as the Coast Range. Between the Los Angeles and Santa Ana Rivers these hills have an altitude of but a few hundred feet above the sea, and scarcely deserve to be called a mountain range; but south and east of the Santa Ana River they attain an elevation of three or four thousand feet, and are as rugged and precipitous as the Sierra Madre.

The valley thus inclosed between the two ranges mentioned, although subdivided by low ridges or spurs of the Sierra Madre, extends from the base of the mountains west of San Fernando to the foot of Mount San Bernardino on the east, a distance of about 90 miles Its total area is about 970 square miles.

The other great irrigation region lies between the Coast Range of hills or mountains and the Pacific Ocean, extending from Santa Monica and Los Angeles on the north, to Newport and Tustin on the south; its total area being about 800 square miles. Along the immediate margin of the sea coast are a few isolated hills, but in genera the valley slopes directly and uniformly from the Coast Range to the low cliff or bench overlooking the sea beach.

The water supply.

Three rivers head in the upper or Sierra Madre range and its eastern prolongation—the San Bernardino Mountains—and after crossin both the great valleys or plateaus described, breaking through th Coast Range between them on the way, they empty into the ocean These streams are the Los Angeles, the San Gabriel, and the Sant Ana Rivers. They receive directly, or indirectly by sub-surface channels, the drainage of the entire southern slope of the mountains i which they rise: an area amounting in the aggregate to 1,887 squar miles. The Los Angeles River drains 320 square miles, the San Gabrie River 356 square miles, and the Santa Ana River 1,211 square mile of the San Bernardino Mountains, and about 76 square miles of th Coast Range, via Santiago Creek. The Santa Ana River is therefor much the largest stream. Its maximum discharge is estimated a 1,000 to 1,500 cubic feet per second. No opportunity was afforded th department of gauging the stream in flood. In the summer season large portion of its waters sink in its rocky bed, before entering the Sa

Bernardino Valley, but previous to reaching its second cañon through the Coast Range, it receives the drainage of numerous tributaries which likewise sink on emerging from the mountains, but flow in subterranean courses and reappear in the main channel in the form of springs. This peculiarity is common to all three of the rivers. Through the coast valley their beds are of quicksand, in which a considerable part of their volume is again lost before finally reaching the ocean, the percolation seeming to extend underneath the entire plain in layers of sand and gravel between strata of clay. These subterranean streams furnish the supply for a great number of artesian wells, used to a large extent for irrigation. As far as at present explored, flowing wells may be obtained over about 300 of the 800 square miles of the coast valley.

Necessity for irrigation.

The necessity for irrigation to insure success in agriculture and horticulture, is quite as great in San Bernardino, and in parts of Los Angeles County, as in the San Joaquin Valley; but on account of the greater scarcity of water the higher value of many of the crops produced, and the wider range of experience attained in the art of irrigation in Los Angeles and San Bernardino, where it has been practiced to some extent for one hundred years past, the necessity for it is more generally appreciated, and water rights and privileges have a greater real value than in the San Joaquin Valley.

Conservation of the water supply.

The scarcity of water has in many places brought about the construction of costly and elaborate works for preventing its waste. This has been effected by conveying it in iron pipes and conduits of brick or stone masonry, concrete, or wood, and providing for its storage in reservoirs. The necessity for its economical use has furnished interesting examples of what may be done with a small quantity of water when carefully applied. This particular subject will be taken up under the head of "duty of water," in chapter three, of this part of my report. I call attention to Appendix I, where will be found an account more in detail of the works, practice, and results of irrigation in the regions just spoken of.

Works and Practice of Irrigation.

Area irrigated.

The total area under irrigation in Los Angeles and San Bernardino Counties is estimated at 82,485 acres, of which 57,853 acres are irrigated from natural streams, principally from the three main rivers and their tributaries; 6,622 acres from springs, springy swamps, or *cienegas* as they are locally termed; and 18,000 acres from artesian wells.

Ditches, canals, cienegas, and wells.

The ditches already constructed are numerous, 130 to 140 all told, large and small. Their aggregate length is probably not less than 450 to 500 miles. The works are divided into the following groups:

Los Angeles River—Seven ditches, irrigating 8,000 acres in and around the City of Los Angeles.

San Gabriel River—Three ditches, irrigating 3,905 acres in the

interior valley between the Coast Range and the Sierra Madre, and 23 ditches, irrigating 19,303 acres on the lower portion of its course through the coast valley.

The Santa Ana River—Eighteen or 20 ditches, irrigating 8,935 acres of the interior valley above the Coast Range, in San Bernardino County, and four ditches, irrigating 9,750 acres of the coast valley below the Coast Range, in Los Angeles County.

Small streams from the Sierra Madre and San Bernardino Mountains—35 independent works of more or less importance, irrigating 5,495 acres of the plateau and valley lands adjacent to the mountains

Small streams from the coast range—18 or 20 little ditches, irrigating in the aggregate some 2,480 acres in the great coast valley, the San José and Temescal Valleys, and the Valley of San Juan Capistrano.

Cienegas or springs in Los Angeles County—26 different works (ditches, pipes, etc.), irrigating about 4,847 acres scattered in various localities.

Cienegas or springs in San Bernardino County—8 or 10 smal ditches, irrigating about 1,775 acres.

Artesian wells in Los Angeles and San Bernardino Counties—950 tc 1,000 in number, irrigating approximately 18,000 acres.

Character of crops cultivated.

It is estimated that nearly one-third of all the irrigated lands o Los Angeles and San Bernardino Counties is devoted to semi-tropica fruits (orange, lemon, lime, olive, etc.), and vines. In many locali ties attention is exclusively paid to these products, although of cours in all irrigating communities some space is devoted to gardens, smal fruits, and deciduous orchards, with occasional patches of alfalfa This is the character of the irrigation from the Los Angeles River; ir the Duarte settlement; in the upper San Gabriel Valley, irrigate from the San Gabriel River; in the settlements of Anaheim, Orange Santa Ana, Tustin City, and Riverside, irrigated from the Santa An River; along the San Gabriel fruit belt, in the vicinity of the Missioı San Gabriel, where the lands are watered from cienegas; in the Pasa dena settlement, irrigated from the Aroyo Seco; in the Cucumong settlement, irrigated from cienegas, and in several other simila centers of farming population.

Character of the irrigations.

This class of crops requires watering in the spring and summeı when the streams are low, so that unlike the irrigated lands of th San Joaquin Valley, watered from the streams that are in fullest flo when the summer sun melts the snows at their heads—furnishing th greatest abundance of water when it is most needed for irrigation– the season of greatest demand is here at a time when the supply i least. Were it otherwise, the area of irrigated land would be greatl increased, as in the winter season a large volume of water runs t waste unused and undesired.

Soils and crops.

The lands most preferred for fruits and vines are the sunny slope along the mountain plateaus, and the bench lands whose soil is a re loam. In the sandy, alluvial bottoms the crops most irrigated aı corn, potatoes, beans, root crops of all kinds, alfalfa, and barle These take up the bulk of all the irrigated territory not devoted t

the other products described. In the coast valley, where artesian wells furnish the water supply, this class of crops is predominant, although fruit is cultivated to some extent in all localities.

IRRIGATION FROM KERN RIVER.

Kern River, and the canal system deriving its water supply therefrom, is described in detail in Appendix B of this part of my report. Only a brief general review of the whole field will be given here.

Kern River and its Delta.

The influence of latitude as affecting the discharge of the streams rising in the Sierra Nevada, is prominently shown in the case of Kern River. It is a fact so well known as scarcely to require mention that the rainfall on the mountains, as well as in the great valley, constantly diminishes as we proceed southward from one extreme of the basin to the other, so that, although Kern River has a mountain watershed much greater than any other stream south of Feather River, and heads among the loftiest mountains of the Sierra Nevada, its discharge was less during the past season than that of the Stanislaus, Tuolumne, San Joaquin, or Kings Rivers, all of which have watersheds of less extent, but situated further north. Were there as great an amount of water drained off from each square mile of the Kern River watershed as from that of Feather River, for example, it would be by far the largest stream in the San Joaquin Valley. As it is, it plays a most important part in the agricultural development of the driest portion of this great irrigation region. The discharge of the stream in 1879 cannot be taken as a criterion of its normal flow, as the season was one of remarkable scarcity. In that year the gaugings of this Department showed the maximum discharge to have been 1,231 cubic feet per second, which occurred in the month of May, while the least discharge of the year was in October, when the flow was but 146 cubic feet per second for a few days.

The delta of Kern.

After leaving its cañon the river flows between gravelly bluffs one hundred to two hundred feet high, for a distance of eighteen miles before reaching the valley proper. At this point it has been wont to spread in divers channels seeking an outlet into Kern, Buena Vista, and Tulare Lakes. The easternmost of these old channels was called "Old South Fork," which entered Kern Lake at its eastern extremity, Panama Slough and Old River were two other prominent channels, which in quite recent times carried a large portion of the stream in a southerly direction into Kern and Buena Vista Lakes. A fourth channel, called Goose Lake Slough, ran in a northwesterly direction into Goose Lake, and thence into Tulare Lake. From the mouth of Old South Fork, where Goose Lake Slough was lost in the swamp lands, the distance is almost forty-five miles, which marks the extremities of the delta.

The channels and the lakes.

The present channel of the river follows a southwesterly direction between Old River and Goose Lake Slough, emptying into the Buena

Vista Slough, four or five miles north of Buena Vista Lake, an about 22 miles from its point of entrance into the valley. Buen Vista Slough, which lies at the western extremity of the valle against the hills, forms the overflow channel of Kern and Buen Vista Lakes, towards Lake Tulare. When Kern River is dischargin into it, the water will flow either southward, into Buena Vista Lak or northward, over a long belt of swamp land, into Lake Tulare, unti the former becomes filled to its utmost capacity, when all the wate will flow northward. From the mouth of the cañon, the distance b the present channel of the river to its junction with Buena Vist Slough is about 40 miles. With the exception of the first four or fiv miles of this distance, the bed of the stream is composed of shiftin quicksands, and is of irregular widths, from 150 to 800 feet. The bank are low and unstable, consisting of a sandy alluvion.

Early irrigation in Kern.

The introduction of irrigation into Kern Valley dates back to th earliest settlement of the county, the first ditches having been co structed in 1858 to 1860. Up to 1867 but little progress had bee made, either in population or in the area of irrigated land, for at th time not more than 650 to 700 acres had been artificially watere The ditches supplying these lands were all taken from Old Sout Fork and Panama Slough, which then carried the greater portion the waters of the river. Subsequent changes caused these streams become choked at their heads, so that it was with difficulty that th could be made to carry a sufficient volume of water to supply th ditches. These fluvial changes, commenced by the flood of 1862, we completed by that of 1867–68, and the channels, which were on main forks of the river, are now canalised and made artificial stream so far as their capacity for transmission of water is concerned.

The river is now confined entirely to one channel, all the othe being converted into canals, for a short distance at least, and the flo of water into them controlled by head-gates.

Districts and Canals in Kern.

These old channels naturally divide the delta of the river into number of districts, as fully described in the Appendix referred These divisions may be summarized as follows:

District No. 1—Between Old South Fork and Old River: To area, 80,000 acres; number of canals, 5; aggregate capacity of cana 895 cubic feet per second.

District No. 2—West of Old River and south of New River: To area, 64,000 acres; number of canals, 9; aggregate capacity, 348 cu feet per second.

District No. 3—Between New River and Goose Lake Slough: Ar 70,000 acres; number of canals, 11; aggregate capacity, 1,924 cu feet per second.

District No. 4—Swamp lands south of Tulare Lake: Area, 103,(acres; number of canals, 2; aggregate capacity at head, 3,370 cu feet per second.

District No. 5—North of Kern River and Goose Lake Slough: Ar 360,000 acres; number of canals, 6; aggregate capacity, 645 cubic f per second.

Total number of canals and ditches, large and small, 33; total length of main canals and branches, 275 miles.

Many of these canals are not used for irrigation, and show a large capacity, because they have wide head-gates, and open out into large sloughs. The total area under irrigation the past season was about 38,800 acres, of which one-third is estimated to have been devoted to alfalfa, and the remainder to cereals, Indian corn, potatoes, beans, and miscellaneous products.

The irrigation system.

There is no other stream in the State from which so many canals and ditches have been made to divert water as Kern River. The low banks of the river, and the rapid slope of the land away from it, rendering this a simple and inexpensive matter, are the causes which have multiplied the number of canals to such an unnecessary and extravagant extent. Nature has been too kind in the disposition of her favors, and the result is a canal system which is wasteful of water. The difficulty of controlling, apportioning, and measuring the supply to each claimant from a stream of this character has been the source of bitter wrangling over the division of the waters of Kern River. Had the difficulties of diverting water at points through the valley been greater, a few large canals, with capacity sufficiently large to serve the whole irrigable area, would have been constructed, the cost of which would probably not have exceeded the aggregate cost of the many now in existence, but they would have effected the distribution of the supply much more equitable than it can now be accomplished, with less loss of the precious element in the canals themselves, and with a saving of the great loss now suffered in the lower section of the river bed, in reaching the works which head near the middle and western side of the valley.

The soil of Kern.

The soil in the irrigated section is a sandy alluvium, particularly within the limits of the delta, which has been subject to periodical overflow, where decayed swamp vegetation has added fertility to the land. On the plains north of Kern River the soil is of similar texture, but without the considerable admixture of vegetable matter. The land has never been subject to overflow and is dry to a great depth. With little exception it is well adapted to irrigation, and although it all absorbs water greedily, it becomes highly fertile, mellow, and productive under irrigation when properly cultivated. As time goes on, it absorbs less and less water, and is more easily and economically cultivated.

Recent progress in irrigation.

Much progress has been made in irrigation in Kern Valley within the past five years, not only in the area over which it has spread, but in the methods employed for the distribution and application of water. This progress has been in the direction of securing greater economy in the cost of preparing land and applying water, as well as in economizing the supply, which is quite as important. Within a very short time the area of land irrigated by Kern River promises to be increased many fold. The present season will probably add more than 25 per cent. to the acreage of the past year.

IRRIGATION FROM TULE RIVER.

The channel of the river.

Tule River enters the valley in Tulare County, about 18 miles fron the southern boundary thereof, and its channel extends westerl down a plain sloping from 20 to 2 feet per mile, a distance of 3 miles, to Lake Tulare. The lands through which it runs are generall sandy; its bed is upon a loose deposit of sand, and its waters seldon reach far into the plain before being swallowed up in this great mas of dry detritus. In particularly wet seasons, and through th months of spring, when there has been heavy snowfall during th preceding winter, Tule River water reaches Tulare Lake above groun for several weeks, or months even, at a time; but this does not occu sometimes for a series of years.

Tule River water supply.

Thus, the water supply from Tule River, small in quantity an uncertain as to time of presentation each season, is in a great mea ure lost in the deep sands of its bed and the surrounding countr soon after entering upon the plains, and indeed, to some extent, befo it has left the foothill region.

Irrigation from Tule River.

The neighborhood of Porterville presents the principal region irrigation. The soil is generally fertile, particularly well adapted wet farming, and produces abundantly with very little water, if it ca be had regularly at the proper times. Small grain is cultivated irrigation to a greater extent in proportion to the total area water than in most irrigation regions in the State.

Works and practice of irrigation.

No detailed examination was made of the works and practice f irrigation from this stream, seeing that there was nothing to be learn l which might not be studied to better advantage elsewhere. So far s known, there are twelve canals or ditches which conduct water f r irrigation from it. They are all small; some of them capable of ca- rying only eight to ten cubic feet of water per second, and their agg- gate capacity is about 350 cubic feet per second. The largest area f land irrigated in any one year was 4,000 to 4,500 acres; and, duri g the season of 1879, probably not over 2,000 acres were fully water l. This last statement is from information, and not from examinatic s made by this Department.

The system of works.

There exists a great necessity for a better class of works in t is region. A consolidation of interests to take water out from the stre n in about two or three good canals, at higher points than where m st of the ditches get their supply now, would result in a great saving of the precious element, which, as said before, is lost in the sandy b ls of the natural channels.

IRRIGATION FROM THE KAWEAH RIVER.

The Kaweah River.

The Kaweah River enters Tulare, or upper San Joaquin Val y, from the Sierra Nevada Mountains, and runs westerly to Tulare La e.

The delta of this river commences, as it were, within the foothills, seeing that the mouth of its cañon is filled with detritus of its own production and depositing, for several miles above the edge of the plains, and the river spreads through the uncertain and obstructed channels of a swamp, almost before it has left its rock-bound course through a mountain cañon. Thus, although the Kaweah is a somewhat more reliable source of supply than Tule River, because it has a larger and a higher drainage area, yet a great portion of its waters are also lost in the depths of the sands, gravel, and light alluvial soil with which it has built up the plain for many square miles in front of its point of emergence from the mountains.

The delta of the Kaweah.

This is the Kaweah delta. From the cañon above Wutchumna Point to Tulare Lake it is thirty-nine miles in length; falling in that distance from an elevation of 520 feet above low water in the ocean, to the plane of the lake, about 190 feet above the same level. In the upper portion its grade is at points as much as 30 feet per mile, alternated by comparatively flat and swampy tracts heavily overgrown with trees and underbrush. Near the lake the plain falls only two or three feet per mile, and without irrigation is dry and barren.

The channels of the Kaweah.

Down this sloping delta plain the Kaweah flood-waters find their way through eight or ten channels whose beds are upon deep sand deposits, particularly near the mountains, and which occasionally are lost altogether in some swampy tract—the waters partially emerging below into another channel under some other name. About half way down the plain from Cross Creek on the extreme north, to Outside Creek on the opposite border, the width of the delta is eighteen miles, but these channels approach each other lower down and enter Tulare Lake only about ten miles apart.

Irrigation from the Kaweah.

Irrigation commenced in the neighborhood of Visalia and Farmington at an early day in the settlement of the country; a number of small farm ditches were in use in the period between 1857 and 1860, and possibly some had been built several years before the earliest date mentioned. The principal irrigation from this source is now in the same neighborhood, though a part of the Kaweah water is conducted southerly, toward the town of Tulare; and the northern branch of the stream, known as Cross Creek, delivers another portion to two ditches which lead their supply to the Mussel Slough irrigation region. Corn, field vegetables, alfalfa, and orchard produce are the principal crops cultivated, though small grain is occasionally raised by irrigation.

Lands and soil.

From the fact that there are natural swamps, as before described, it may well be understood that some lands are moist without irrigation; and such is the fact; but these dry out rapidly when cleared, and irrigation then becomes a necessity. The soil in this district is very variable in quality, the modern wash from the mountains brought down by the river being unevenly distributed over a plain of a different composition, the soil of which has evidently been

deposited at an earlier geological period. The recent alluvions, where not too sandy, have made good soil; but the old plain land is frequently highly alkaline, and sometimes cemented so as to be almost unfit for cultivation.

Canals and water claims.

There are in all sixteen canals—claimants to water from the Kaweah, with ditches constructed out from some one of its branches. In several cases these claims are the result of a consolidation of a number of small ditch interests, so that there are three, four, or five small ditches to an interest. In other cases the claims are for water to be conducted from one natural channel to another, simply to supply some other work having a separate claim at a lower point.

Diversion and use of water.

Fourteen of these canals and ditches located in the neighborhood of Visalia, in the Kaweah delta proper, have an aggregate capacity of between 750 and 850 cubic feet per second; but three of the largest, as before explained, serve as leaders for other claims whose water is taken out at a lower point, so that the aggregate capacity of the system to divert water from the streams and use it in irrigation, is not over 550 to 600 cubic feet per second. The largest area of land ever brought under irrigation by these works was 8,000 to 9,000 acres, but during the season of 1879 the water supply failed, and probably not over 3,000 acres were thoroughly irrigated. The two canals which take Kaweah River water into the Mussel Slough irrigation region have an aggregate maximum capacity of 150 cubic feet per second. During the season of 1878, these works irrigated 13,343 acres of land; but in the season last past the water supply, as it was diverted and used, admitted of the irrigation of 3,150 acres only.

IRRIGATION FROM KINGS RIVER.

Kings River.

A description of Kings River, somewhat in detail, and an account of the works and practice of irrigation dependent upon its waters, will be found in Appendix C to this part of my report. The leading facts, with respect to the field, are here brought together in a condensed form. This river is one of the principal sources of water supply for irrigation in the great San Joaquin Valley.

Ditches and water claims.

There are, in all, twenty-two claims to water for ditches constructed, which may be regarded as in existence along its course. Some of these are consolidated—as many as three in one management or company. Most of them are for small amounts of water, and of several it may be said they scarcely abstract water from the stream, for, being used on the low bottom land adjacent, it doubtless finds its way back into the river again almost immediately.

Upper Kings River ditches.

Five of these ditches take water from the north bank of the river, near the foothills. Of these, two are very small and are consolidated with a third. There are, then, three separate canal interests diverting water in this locality, the total capacity of whose canals is 900 cubic feet per second. This set of canals may be called the Upper

Kings River group. They distribute water about Centerville, near the river, and thence down to and below Kingsburg on the San Joaquin Valley Railroad, 18 miles away, and also towards and beyond the town of Fresno, on the railroad likewise, and situated 19 miles from the source of supply. The total area irrigated by these ditches in 1879, was 13,000 acres, and the maximum amount of water diverted during the irrigation season was 633 cubic feet per second.

The Centerville bottom land ditches.

Four quite small ditches take water opposite to and below the Upper Kings River group, and distribute it, for the most part, on the bottom lands opposite and below Centerville. These ditches have an aggregate capacity of about 50 to 60 cubic feet per second, but as explained above, they do not diminish the supply that much. Possibly as much as 2,500 acres have been irrigated by this last set of ditches, which may be appropriately called the Centerville bottom land group.

The Mussel Slough ditches.

Six ditches take water from Kings River on the south side, below the railroad crossing; of these, one is so little removed from the condition of a natural channel, and the irrigation from it is so little different from the natural inundation of the low lands, that it has been omitted in some of the tabulations contained in Appendix C.

The five other ditches in the neighborhood were carefully studied and reported upon. Their aggregate maximum capacity is 890 cubic feet per second, and during the season of 1879 there were 37,910 acres irrigated by their waters, which reached a maximum discharge of about 1,700 cubic feet per second in the aggregate.

This irrigation is in what is known as the Mussel Slough country, which is partially supplied by two canals from the Kaweah branch known as Cross Creek, and the ditches may be called the Mussel Slough group.

During the last season there were 41,060 acres in all irrigated in this district. In the season of 1878 these two Kaweah ditches irrigated 13,343 acres, and had the water supply not have failed in that stream, they would have covered fully as much during 1879; so it may be said that, in all, 51,253 acres have been brought under irrigation in this region.

The lower north side ditch.

One canal takes water out upon the plains northward from the river, below the railroad crossing, and opposite the Mussel Slough country, and there are six small ditches which appropriate and distribute water through the delta, further down stream.

During the past season the total area irrigated by these ditches was about 8,500 acres, and the maximum amount of water diverted was ——— cubic feet per second, in canals aggregating ——— cubic feet per second in capacity.

In the examinations and measurements made, only the largest canals were gauged; these are nine in number, three of the Upper Kings River group, five in the Mussel Slough group, and one on the north side of the river, opposite the Mussel Slough country.

IRRIGATION FROM THE SAN JOAQUIN.

The River and its Districts.

The San Joaquin River comes from the Sierra Nevada Mountains in a cañon, and flows into the valley within a bed much depressed below the rolling lands by which it is flanked. In this respect it differs from the Kings and other rivers south of it; and although those to the north emulate it in its retirement below the general level of the plains, yet it surpasses them all, and is probably the most difficult of the irrigation streams to draw from for the watering of the high plains which must depend upon its floods. For sixteen to eighteen miles below its cañon proper, the waters of this river are 75 to 200 feet below the level of the rolling lands which border it; and bluffs standing almost perpendicular at points along its course, guard the approaches. Thus, until quite lately, there has been no effort made to construct canals out from it in this upper portion of its course—for the undertaking is an expensive one—and the high plains have remained dry and uncultivated.

Water supply.

The comparatively large volume of water carried by the San Joaquin, and its proximity to great areas of land well adapted to wet farming, render it one of the most important as it is the most forbidding of the irrigation sources in the great valley. During the past season it presented a greater volume of discharge than any of its fellows, except the Tuolumne, far surpassing Kern, although it has a less drainage area. The tables given in the next chapter illustrate this sufficiently without citation of figures here.

The interests of navigation.

While, however, the considerable volume brought out into the valley by the San Joaquin River is regarded with satisfaction, it must not be supposed that it is all available for irrigation. Its fellow streams of the extreme upper valley, the Kings, Kaweah, Kern, and others, may give up all their store to the irrigator, but the San Joaquin must not. It is the principal branch of a navigable river which lies in the bottom of a great valley whose future must depend greatly upon cheap transportation. It has not yet been shown (as elsewhere in this report demonstrated) that the diversion of water from this stream and its tributaries will not impair its navigable qualities; and it is more than probable that the interest of interior commerce will demand a careful and provident use of it, from the upper reaches of this great valley highway.

The irrigable plains—soils.

South of the San Joaquin the plain is even and inviting to the would-be irrigator. The soil is deep, receives water readily, and yields an abundant return for the labors of those who till it, as evidenced by the results of irrigation with water from the Kings River, brought in the Fresno and Kings River Canal, twenty-two miles from its source to within six miles of the San Joaquin.

North of the river the foothills or rolling lands extend far down into the valley. "Hard pan" subsoil approaches near to the surface and often lies almost bare. Thus, except where along some little

stream a recent alluvial deposit has been made, the soil is not favorable to irrigation until near midway down the plain.

Here the river is more easily approached on both sides. The plain is only 35 to 50 feet above its bed, and the soils are lighter and better suited to wet farming, while those to the south are generally deep and sandy, and in a great measure free from alkali. The soils on the north bank are still heavier (except where creek washes have deposited sands), varied with alkaline tracts, are uneven in surface, and frequently quite shallow upon the hard pan subsoil.

Canals from the San Joaquin.

The irrigation canals which derive their supply from the San Joaquin River, are two in number—the Chowchilla Canal and the San Joaquin and Kings River Canal—both of which head near the great bend of the river, where, after coursing across the valley from the mountains, it turns northward and follows parallel with the central valley axis.

The Chowchilla Canal.

This work is highest on the river of those now in use, and diverts water upon the plains on the east side. Its total length is about 30 miles. As its course is nearly parallel with the river it necessarily crosses the drainage ways of a number of watercourses which seek an outlet in the main valley drain, down the plains from the east. These streams are the Cottonwood and Berenda Sloughs, the Fresno, Mariposa, and Chowchilla Creeks. They have been wont to spread out in many shallow channels on the lower portion of their course, and in time of flood sometimes cover the plain with a broad sheet of water, for the want of good channels to run in. To maintain a canal whose banks form a barrier in the way of this drainage, is a difficult matter, and were it not cut in very hard firm subsoil over the greater portion of its distance, it would have been almost obliterated by a single flood. As it is, the banks are broken every season of high water. When these breaks occur the lower bank is restored, but on the upper side the canal water finds frequent outlets, to spread in large shallow ponds.

Extent of capacity and irrigation.

The total capacity of the canal, just below the lower headgate, where it is an artificial channel of good form, is about 117 cubic feet per second; above this point it occupies the bed of an old slough, and its capacity may be taken at 200 to 250 cubic feet per second. Below the second headgate at the end of the slough section, the channel diminishes constantly in size, so that at the lower end its capacity does not exceed 25 cubic feet per second. The canal is used for the irrigation of wild grasses and alfalfa, a few hundred acres altogether being devoted to grain. The total area watered the past season by it was about 14,400 acres, of which 13,000 acres are on the Columbia Ranch, within five miles of the head-works, and the remainder on the Chowchilla Ranch at the lower extremity of the canal. Between these widely separated points the canal is only used for watering stock.

The lands irrigated.

Much of the land over which the Chowchilla Canal passes is of little value for agricultural purposes, on account of the outcropping of a peculiar hard pan, resembling soft sandstone in its composition and wholly imperious to water. The soil on the irrigated portion of the Columbia Ranch is heavy and retentive of moisture, requiring the most scrupulous attention to drainage after each application of water to prevent the effects to both soil and crops which ensue from excessive flooding. The larger portion of the wild grass lands are irrigated without system, and water is poured over them in the most indiscriminate way. The soil of the irrigated lands at the lower end of the canal is a deep sandy loam, much better adapted to irrigation than that above, just described. It absorbs more water and retains it a much longer time, requiring fewer applications through the season. A fuller description of the canal in question and the practice of irrigation under it will be found in Appendix D.

The San Joaquin and Kings River Canal.

This canal heads at the junction of the Fresno Slough, the overflow outlet of Kings River and Tulare Lake into the San Joaquin River. A dam of brush and framework thrown across the river just below the mouth of the slough diverts water into the canal upon the west side of the valley. At the time of its construction, in 1871, it was the most important irrigation work that had been attempted in California, and it still ranks among the leading constructions of its class. Its total length, to the present terminus at Orestimba Creek, is 67 miles, being greater than that of any other irrigation canal in the State. It commands an area of about 283,000 acres, which includes all the lands lying between it and the river, about 130,000 of which is low and naturally subject to overflow in seasons of ordinary high flood. Its capacity upon the upper portion of its course is now about 600 cubic feet per second. During the past season the area irrigated was about 30,000 acres, the greater portion of which was devoted to cereals.

Soils—alkaline adobe.

The soils of the irrigated lands vary greatly in character. For 35 miles from its head the soil over several miles of territory below the canal is a black alkaline adobe, underlaid with a subsoil of hard-pan differing from the hard-pan on the opposite side of the river, in that it consists of yellow marl, and is not wholly impervious to water. This character of soil is difficult to irrigate properly, as it absorbs very little water, quickly dries out, bakes upon the surface, and requires frequent applications to produce crops. It must be carefully drained at the same time, and indeed, it demands the utmost skill and watchfulness to avoid the many dangers attending the indiscriminate use of water.

Soils—sandy loam.

Along the river between Firebaugh's and Hill's Ferry, there are large areas of sandy loam well adapted to irrigation. Below Los Baños Creek the character of the soil is suddenly changed to a deep loam, compact, but well adapted to irrigation, and much more tractable as well as more fertile than the alkaline adobe soils further up the valley. Irrigation is progressing rapidly upon this latter class of soils, which have, however, enjoyed its privileges but one season since

the extension of the canal from its former terminus at Los Baños, to Orestimba. The farmers are rapidly availing themselves of the advantages bestowed by irrigation, and during the past fall that section has been one of busy activity in the preparation of new land for this class of cultivation.

Dos Palos and Temple Sloughs.

Two sloughs leaving the river a few miles below Firebaugh's have recently been deepened, enlarged, and converted into canals, and during the past season some 8,000 or 10,000 acres of the same land commanded by the San Joaquin and Kings River Canal have been watered in an unsystematic way by means of these new channels of diversion. They have substantial headgates and can be made to serve a useful purpose in irrigation, but as yet they are only used to flood wild grass lands, to freshen the feed for stock in the drier months of the year.

A projected work.

The Upper San Joaquin River Irrigation Company now have a canal in course of construction out from the San Joaquin River on its south side, commencing several miles below the cañon. But little is known in this office concerning these operations. The work is an expensive one, as may be supposed from the notice heretofore given of the character of the approaches to be traversed. The route leads out into a fine body of irrigable land much in need of water, and could the enterprise be made successful as an engineering work, doubtless it would develop another irrigated district of importance.

IRRIGATION FROM THE FRESNO RIVER.

The Fresno River.

The Fresno River enters upon the plain about 12 miles north of the San Joaquin. It is a smaller stream than either of the other rivers, so called, of the valley, and being intermittent in its flow, should properly be called a creek—according to the popular nomenclature of the State. Under these circumstances, it constitutes an uncertain source of water supply for irrigation.

The lands irrigated.

The lands adjacent to its point of departure from the foothills or mountains, are rough and rolling in shape, and of a poor soil composition, with a sandy hard-pan subsoil near the surface, and they are consequently not well suited to irrigation. On approaching the line of the San Joaquin Valley Railroad, which lies generally about midway between the mountains and the trough of the valley, some better land is encountered—the surface becomes smooth and the soil of a rich sandy loam. At about this point a canal has been constructed out from the river on the south side. The water is used upon land within nine miles of the headgates, and there has been as much as 3,000 acres irrigated in one season.

Works and irrigation.

The canal has a maximum capacity to divert water from the river, of about 300 cubic feet per second, but it is doubtful if this amount can be distributed promptly without injury to the lower portion of

the works, with their present dimensions. During the past season there was water flowing in this canal from January 17th to June 11th, the maximum flow being about 200 cubic feet per second, occurring in March and again in April. The greatest average for any one month was in April, 156 cubic feet per second, and there were 1,500 acres irrigated. The cultivation here is almost entirely alfalfa and small grain.

IRRIGATION FROM CHOWCHILLA RIVER, MARIPOSA AND BEAR CREEKS.

The creeks.

These creeks enter upon the east side plain of the San Joaquin Valley, between the Merced and the Fresno Rivers. Like the last mentioned stream, they drain only the lower mountains and foothills, and consequently have but an intermittent supply. The San Joaquin River on the south, and the Merced River on the north flank, head behind the drainage basins of these smaller streams, and securc the snow waters from the higher ranges of mountains; but for a few days immediately after heavy storms in winter, the Chowchilla, Mariposa and Bear Creeks present large volumes of water, which course across the plains in numerous small channels, become absorbed into the dry soil, or lost in the swamps along the San Joaquin River, in the trough of the valley below.

Uncertain supply of water.

As yet there has been but little irrigation from these sources. The uncertainty as to time and volume of presentation of the water is such that the investment of capital or labor in works for its diversions and use becomes extra hazardous, and the liability to conflict of interests between appropriators is increased.

Irrigation in Mariposa.

There is some irrigation from these streams, or some of them at least, within the foothills in Mariposa County, but no examination has been made of the works and the results thereof. They are all very small, however, being, so far as known, individual farm ditches only; yet, had time and means sufficed, an examination of their workings would have been made, for as small or even smaller beginnings have been studied with profit in other places, as, for instance in San Bernardino and Los Angeles Counties.

The Robla Canal.

One canal—the property of the Robla Canal Company—out upon the plains, deriving water from Bear Creek, is 12 miles long, and according to information, has a capacity of about 120 cubic feet per second. But little use has been made of the water, however, and the extent of irrigation is not known.

IRRIGATION FROM THE MERCED RIVER.

The river and its bottom lands.

Another of the great fountain heads of irrigation to bring fertility to the San Joaquin plains, is the Merced River. This stream, like the San Joaquin, Kings, and Kern Rivers, and others to the north, also heads among the high, snow-capped peaks of the mountains, behind

the outstanding spurs and ridges, such as are drained by the creeks last mentioned. Its waters from the highest sources, find a passage through the Yosemite Valley and thence to the plains along deep and rocky cañons. In its course down the plain towards the trough of the valley, a distance 36 miles in a straight line, the Merced River is a very tortuous and at points contracted stream, evidently deficient in capacity. It is flanked throughout by a low bottom land formation, depressed 40 to 80 feet below the general level of the adjacent plains, and at times of flood it naturally spreads from its main channels, making short passages through side channels of more direct alignment and greater grade.

Irrigation in the Merced bottom lands.

Thus, these bottom lands are naturally well watered; but to prevent uncontrolled flooding they have been protected by small embankments at particularly low points along the river's course, and thus it has been found necessary to irrigate them. Eight miles below the cañons the Merced bottoms reach their greatest width—about three miles—thence they narrow down, within the next eight miles, to about one mile from bluff to bluff, and continue to become still more contracted and less sharply defined as they approach the level of the plains, on nearing the trough of the great valley at the San Joaquin River.

The irrigation along these bottoms is all conducted by small farm ditches and has not been studied. The acreage thus watered, according to information, is about 1,500 to 2,000 acres, cultivated chiefly in alfalfa, corn, field vegetables, garden produce, and fruits.

The Farmers' Canal, south of the Merced.

A large canal has just been brought into operating condition on the south side of the Merced River by the Farmers' Canal Company. This work was commenced in May, 1873, has been several times almost abandoned, but now is in a condition to afford a return to its proprietors.

The canal takes water at a point about four miles above the Town of Snelling and three miles below the settlement known as Merced Falls—where the river is flanked by high, rolling lands—and about as high up on its course as it can be approached on a grade from the plains, at a moderate expense. Thence the route lays along a rolling sidehill and through a tunnel 4,000 feet long, a distance of six miles, to Canal Creek. The bed of this creek is used to carry the water forward for thirteen miles, and thence it is to be distributed principally on the plains between the river and the Town of Merced.

The company claims 100,000 "inches" of water, about one-half of which has been taken into the canal. Irrigation is in progress, but as this is the first season, its extent is unknown.

IRRIGATION FROM THE TUOLUMNE RIVER.

The river and its bottom lands.

Judged by the extent of its mountain drainage basin, the Tuolumne is fourth in the list of rivers entering the San Joaquin Valley, but in actual volume of water habitually brought down, it stands first, as will be shown in the discussion concerning water supply embodied in the next chapter.

This river comes from the mountains through a most forbidding

cañon, below which it is flanked by foothills, merging into rollin lands, and then into a plain standing 50 to 80 feet above its wate surface for 20 miles below the cañon proper. Thence the plain fall as in the case of the Merced, to the trough of the valley, where th river is between banks only 15 to 25 feet in height. The Tuolumn flows in a general direction nearly due west from its cañon to th San Joaquin, the distance, in a straight line, being about 42 mile For 30 miles of this distance it is bordered by plains sufficiently eve of surface to admit of irrigation on a large scale to advantage, an composed of soils particularly favorable to this class of agricultur Its bottom lands are very limited as compared to those of the Merced indeed, for much of its course the high plains hem it in closely.

Projected irrigation works.

Thus far its waters have not been drawn upon for irrigation ove the great plains of the valley, for, next to the San Joaquin, it is th most difficult source to approach on grade from the lands which mo require watering.

Preliminary examinations for canal routes out to the plains fro this river have been made, both towards the north and south, an these will be adverted to hereafter in speaking of the water suppl and irrigable lands.

Mining ditches and irrigation.

High up in the Sierras the Tuolumne furnishes water to two larg mining ditches, one of which delivers its supply at points still we within the mountains, and the other at the edge thereof, near th cañon spoken of.

Irrigation is scarcely a consideration in the distribution of th water—seeing that it is in demand for mining purposes—and th extent of cultivation by its use is very limited indeed.

The La Grange Dam, etc.

At a point about a mile and a half above the Town of La Gran the river comes through the narrow cañon spoken of, with precipito hard rock sides. A timber dam was erected here in 1871, and it sti stands apparently in good condition.

This structure was built for the purpose of diverting water f irrigation, and a survey was made for a canal route from it to th plains north of the river. The site of the dam is an excellent poi for the location of headworks for canals of diversion, but that the co of construction must be at a maximum figure. The line out from th proposed point of derivation to the plains is located for nearly miles over rugged hillsides, and occasionally around bluffs of so rock. The cost of construction on such a route is always great, an the utmost care should be exercised in adjustment of grades an alignment, and in the study of the whole subject, before final actio is taken in such a project.

Irrigation near La Grange.

A ditch about two and a half feet wide leads out from this dam the south side, and supplies water for the irrigation of gardens an vineyards about La Grange upon the low lands and hillsides with the bluffs which flank the river. Another small ditch affords th means of cultivation by irrigation of similar character on the nor

side of the river, at a point two miles further down stream. Nothing definite, however, is known of the extent of the water appropriation, or the results of the use of the supply obtained.

IRRIGATION FROM THE STANISLAUS RIVER.

The mountain basins and their waters.

The Stanislaus River ranks among the first of the more important perennial streams, which take their origin amidst the higher peaks of the Sierra Nevada, descend to the plains through rock-bound cañons, and join the San Joaquin River in the central trough of the valley. For, although its mountain drainage basin is sixth in the list, as to size, in volume of its discharge it may well rank fourth or third, in all ordinary seasons, being surpassed by the San Joaquin, Toulumne, and Merced sometimes only. This is, of course, due to the fact that the fall of rain and snow upon the mountains increases greatly with the latitude, and going north, as a general rule, each of the streams, as far as the Sacramento, drains a greater depth of water off of its basin, other things being equal, than that which precedes it.

The River and its bottom lands.

On leaving the foothills the Stanislaus lies in a deep trough, one hundred to one hundred and fifty feet below the general level of the plains, and is bordered by a very narrow belt of bottom lands. On its further course accross the valley, its grade is so much less than the slope of the plains on either side, that on reaching the point where the San Joaquin Valley Railroad crosses the stream, the low water level is but forty to fifty feet below the adjacent plains. Throughout the lower portions of its course the channel is very much contracted, in places not exceeding sixty to eighty feet in width, and totally incapable of carrying the volume of its flood-discharge, so that the bottom lands are periodically overflowed and cannot be continuously cultivated, although the soil is of the most fertile and productive character.

The soil of the plains—Diversion of waters.

Few of the streams in the middle and northern portion of the State, pass through a territory whose soil is so well adapted to irrigation as the Stanislaus. The high plains on either side are largely composed of a loose sandy loam, whose texture and physical conformation present conditions peculiarly favorable to the successful use of water for crops. The topographical peculiarities of the stream, however, its great depth below, and its light grade through the valley, requiring the location of the heads of canals at points quite a distance up the cañon of the river, in order to attain the elevation necessary for commanding the plains, renders the diversion of its waters comparatively difficult.

Irrigation from mining ditches.

Three locally important ditches have been taken out of the river above Knight's Ferry, and supply water for hydraulic and placer mining as well as for irrigation, and the latter interest is now assuming considerable proportions. These ditches do not extend out upon the plains. Two of them water the orchards, vineyards, gardens, and small fields on both sides of the river, in the vicinity of Knight's Ferry. They head within the mountains above the mouth of the

cañon, along the sides of which they are conducted, either in rock cuttings or in flumes that in places skirt the face of precipitous rock walls. The other canal is far up in the mountains, and supplie water principally in the neighborhood of the Towns of Sonora anc Columbia, in Tuolumne County. These ditches are amongst th works constructed for mining purposes in early years of the State which will be referred to more at length hereafter.

Farmington Water Company's project.

A canal has been projected from the Stanislaus to divert wate upon the plains of San Joaquin County, to the northward, via Little john Creek. A tunnel about 1,900 feet long is required to carry th ditch water into the creek, and this has been partially constructed The diversion of water will be effected by means of a dam, to b located 14 miles above Knight's Ferry, whence it will be carried in canal two and a half miles to the tunnel, the lower end of whic opens directly into the bed of Littlejohn Creek, which is to be use as the main channel of the canal. When completed, this canal ca be made to command the greater portion of the irrigable land lyin between the Stanislaus and Calaveras Rivers, and from the characte of the soils to be irrigated, particularly those of lands situated nea the Stanislaus, a good result may be anticipated.

IRRIGATION FROM THE CALAVERAS RIVER.

The character of the river.

The Calaveras is one of that class of streams which drain a suff ciently large watershed to become torrents in winter, but do not hea high enough in the mountains to be perennial in their flow. Tl forks of the Mokelumne and Stanislaus on either side lap aroun behind, and above the Calaveras, whose main supply comes from tl rains of winter. It is, therefore, in its natural condition, of le value as a supply for irrigation than its neighbors, which are fed i summer by melting snows, and are reinforced throughout the year l perennial springs of the high Sierra.

The Calaveras plains and channels.

From the point where it emerges from the foothills near the villa of Jenny Lind, to its junction with the San Joaquin River, the distan in a direct line, is about 25 miles. At Bellota, about —— miles fro Jenny Lind, the stream forks, one channel passing westward throu Stockton, and bearing the name of Mormon Slough; the other diver ing slightly to the northward, enters the San Joaquin about five mil northwest of Stockton. Mormon Slough is now the principal chann and carries water when the Calaveras proper is dry. In extre floods both these channels are incapable of carrying the volume water seeking an outlet through them, on account of their defecti alignment and condition, and at such times the plains are overflow from numerous side streams that put out from the main channels weak points in their banks. The Calaveras proper has been improv to some extent by the farmers, who have thrown up a low levee both banks for a long distance, cleared out the driftwood, and cu large relief canal on the north side, which at the same time is oc sionally made available for irrigation.

Irrigation and rights to water.

Irrigation has been practiced in a desultory sort of way in occasional dry years, when the wheat fields needed to be fortified and revived by moisture artificially applied, but it is not regularly depended upon and has attained no special system. Both forks of the stream are used for this purpose, and in very dry years like 1877, disputes arise between the farmers as to which fork is entitled to the water; the advocates of each claiming all that may be flowing in the main river.

Waters and sediments.

Before reaching the valley the water of the Calaveras is used again and again for placer and hydraulic mining purposes, and consequently it is always highly charged with finely attriturated sand and sediment. From this fact it is considered specially valuable when applied for irrigation upon the heavier soils of San Joaquin County, the sandy sediment carried by the water when mixed in small quantities with the adobe soil having the effect of rendering it more mellow and tractable.

A little, but not too much, sediment desired.

There are few localities in the State presenting more favorable conditions for the development of a satisfactory system of irrigation than the region that may be reached by the Calaveras. The soils there to be met with are unsurpassed in fertility, but they require the addition, in small quantities, of just that character of material brought down by the stream to render them more easily worked, and in a measure to restore the elements taken away by continued cropping of cereals.

It is not probable that it would ever be necessary to irrigate the whole area of land now under cultivation and susceptible of irrigation, but by supplying the means to each farm for watering small paddocks of clover and other grasses for summer pasturage, and giving the opportunity to all of cultivating garden vegetables, vineyards, and orchards, the value of the land, great as it now is, would be largely increased, and made capable of supporting a denser population.

Years of drouth.

There comes an occasional year, too, when cereals partially or wholly fail for lack of moisture. To provide against such an emergency the works should be of such capacity as to make it possible to resuscitate the failing crops by the addition of the moisture which nature failed to give, and when the works were constructed and in working order, the practice of giving the fields a good soaking in the winter, when water would be abundant, would doubtless soon prevail in all seasons, as a matter of precaution.

Storage of water.

Now, all this implies the storage of surplus water, for the stream being intermittent in flow, must be reinforced in summer by holding back and saving a portion of the flood waters of winter. The geological formation of the country, drained by the river, may be considered as favorable for the construction of many such reservoirs,

although there would probably be found few sites where very great quantities of water could be stored by one dam. Small depressions are numerous, however, where reservoirs of moderate extent could be located. The cost of irrigation canals from the Calaveras River would be small, as compared to that from other streams—owing to its being easily approached from the plains—and the cost of storage works, therefore, would not be altogether in addition (as to actual amount) to what other complete systems will cost per acre irrigated

IRRIGATION FROM THE MOKELUMNE RIVER.

The river through the valley.

From the line of foothills, the distance in a straight line to th mouth of the river is about 38 miles. For the greater portion of thi distance the valley of the river is depressed below the general leve of the plain—in a degree similar to the Tuolumne and Stanislau rivers—before described. The distance between bluffs is half a mil to one mile, and the channel pursues a winding course, bordered b rich alluvial bottom lands, sufficiently elevated above ordinary flood to render them cultivable.

A short distance below Woodbridge the river enters the grea swamp region, and at the head of Staten Island divides into two fork which come together again below the island, entering the San Joaqui in a single channel. All this lower section of the stream, throug the region of swamp and overflowed lands, is subject to tidal actio the scour of which maintains a sufficient depth to render the chann navigable to river craft.

Topographical features—Mining ditches.

Like all of the large streams north of Kings River, the Mokelum is environed by topographical difficulties in the way of the diversio of its waters, and canals to effect this object must tap the strean well up in the foothills to attain the elevation necessary, thus invol ing expensive sidehill work, before the level surface of the pla can be reached. There are no canals in existence for irrigation the valley, but the mining ditches, which tap the stream in t mountains, are used to some extent for that purpose.

Mokelumne Irrigation Company's project.

A large canal has been projected for irrigation on the south side the stream in San Joaquin County, but as yet no work has been do upon it, except to partially complete a masonry dam, located at t wire bridge, a short distance above the Village of Lancha Plar This projected canal is expected to water a wide belt of fertile la lying between the Calaveras and Mokelumne Rivers, where a fi field exists for irrigation.

IRRIGATION FROM CACHE CREEK.

The mountain basin and waters.

Among the many streams entering the Sacramento Valley from t Coast Range on the west, Cache Creek is one of the most importa Were its 1,025 square miles of mountain watershed above the he of Capay Valley elevated to the average height of the Sierra Neva in which the largest snow-fed streams of the State take their orig

we might expect it to be a stream of more constant and uniform flow, worthy of being dignified with the name of river, and ranking with the American, Mokelumne, or Stanislaus, neither of which drains an area as great as that of its catchment basin. As it is, the precipitation of winter is not stored up in the form of snow, to yield a supply throughout the summer, but is drained rapidly off the steep hill slopes, presenting a formidable flood volume for short periods subsequent to each storm, after which the stream subsides into comparative insignificance.

Clear Lake.

A large portion, nearly one-half, of the drainage of the creek is received into Clear Lake, the area of whose surface is about 80 square miles. The existence of this great reservoir has a material influence in diminishing the force and volume of the floods of the creek, and prolonging their flow. From the lake the creek passes through a cañon about 30 miles in length, before entering the head of Capay Valley, receiving two large tributaries from the north. These tributaries, having no broad reservoir in which to spread out their waters, and being wholly uncontrolled and unchecked, furnish the source of the greater portion of the first rush of floods succeeding each heavy rainfall.

Capay Valley irrigation.

Capay Valley, through which the creek passes after leaving its cañon and before entering upon the Sacramento plains, is about 18 miles long and one to two miles in width, the arable land of the valley being almost wholly on the south side of the creek and sloping toward it from the hills, with steep grades. The area of land that may be classed as irrigable in this valley is about 13,000 acres. Its soil is of a character generally well adapted to irrigation, although of a heavy, compact texture. It has a gravelly subsoil, which, with its heavy surface slope, renders its drainage an easy matter—a subject of prime importance in the irrigation of all heavy soils. Where the slopes are steepest the preparation of the land for irrigation is more costly than on flatter land, but irrigation for cereals and all spring crops is not generally essential, as the rainfall is sufficient to mature them without it, and it is, therefore, in demand only for maintaining green pasturage through the summer, and for orchards and vineyards and summer field crops, the convenience and value of which to the individual farmers are sufficient to justify the outlay upon the limited tracts to which it would be applied.

The creek's course across the plains.

On entering upon the Sacramento plains the creek widens out in a channel 500 to 1,000 feet in width, with low banks and decreased grade, but before reaching the Town of Cacheville is confined between vertical banks 20 to 25 feet high and 100 to 150 feet apart, which condition it maintains for several miles; but on approaching the lowland of the Yolo basin the banks drop away, and the stream is free to spread out in a broad delta, seeking the lowest part of the basin, and emptying into the Sacramento River through Cache Slough.

Irrigation and canals.

The waters of Cache Creek have been used for irrigation in an

unsystematic way for nearly a quarter of a century, but the works are still in as crude a condition as if the whole matter was yet an experiment of doubtful utility or value. One of the principal ditches, which commands a large territory of the richest farming lands of Yolo County, in the vicinity of Woodland, was built in 1856, and has been used almost continuously ever since. Its value as an irrigation channel is lessened from the fact that no permanent dam has ever been placed across the creek at its head, and water is diverted by a temporary barrier of brush and gravel, which is yearly swept away, leaving the canal without water until it can be replaced. This cannot be done until the creek subsides, and then the greatest demand is over. The canal is also very much out of repair throughout its length, and its capacity is thereby greatly diminished. The area irrigated by the canal is estimated at about 13,000 acres, all of which, with the exception of 200 to 300 acres of vineyard, is devoted to alfalfa. Two other canals have been taken out higher up on the creek, one of which heads at the upper end of Capay Valley, and irrigates about 280 acres of alfalfa in scattered patches, the other heading about two miles above the foot of the same valley, extends out upon the plains, and irrigates about 200 acres of the same grass, near the Town of Madison. The former of these two canals was intended to supply the entire Valley of Capay, but its construction was stopped after 10 or 12 miles had been built, and although it was originally a very expensive work is now so much out of repair as to be of little service. It first came into use in 1874. The lower canal is about the same length, and is in excellent condition. It is a recent work, and is generally well located throughout.

Other canals.

Aside from these three canals on the south side of the creek, there is one on the north side, which formerly irrigated a large body of land in the vicinity of Cacheville, but has not been in use for about ten years, and is wholly out of repair and not in condition for service.

Three small farm ditches, one near the foothills on the western side of the valley, and two below Cacheville, complete the list of irrigation works from Cache Creek. Of the latter ditches the lowest on the stream is not in use, another only draws water when the stream is in flood, and the third is used for about 200 acres of alfalfa when water is abundant.

A more detailed reference to these works will be found in Appendix E, attached to this part of my report.

Water supply—Clear Lake as a reservoir.

Even in its present condition, Cache Creek is capable of performing a large duty in irrigation, and were the works now in existence placed in better condition and maintained in good repair, the irrigated area would be increased many fold, while by treating Clear Lake as a reservoir for the storage of the surplus waters of winter for use in the season of greatest demand, the effective service of the stream could be made to equal that of the Stanislaus, Tuolumne, or Kern Rivers, for example. Let us suppose that the outlet to the lake were deepened so as to leave its surface six feet below the maximum height it naturally reaches, and a dam were placed in the outlet of a sufficient height to hold back and save six feet in depth in the lake, but not raising the water higher than it ordinarily rises, so

as to avoid injury to lands on the lake borders. With proper outlet sluices to draw off the water when required, there would, therefore, be available for irrigation an amount, in cubic feet, say five times the area of the water surface, or about 11,100 million cubic feet. It would not be necessary to begin drawing upon this store before May, as in ordinary years the tributaries of the creek below the lake would maintain a full supply up to that time, together with the surplus running over the top of the dam. We would then have for the next five months, from May to September inclusive, a continuous discharge of about 300 cubic feet per second, after allowing two-thirds for loss by evaporation. Under a duty of 200 acres per second-foot, which is not too high to expect upon the class of soils and with the character of crops to be irrigated, this surplus water thus saved would effect the irrigation of 60,000 acres. This area would be in addition to that irrigated in the winter and early spring from the normal flow of the stream, as the crops watered during that season would, generally speaking, not be the same as those requiring water in the summer months. At any rate, the winter flow, aside from that stored, would largely assist in increasing the duty of the summer water, and thus enlarging the area capable of being irrigated. For instance, in the neighborhood of Woodland, alfalfa, for which irrigation is principally in demand, is now seldom irrigated prior to July, and even if water were available would not be wetted artificially before May.

Irrigation from Clear Lake.

The total water quantity upon which this estimate of storage has been based—11,100 million cubic feet—would be furnished by a rainfall of about ten inches over the whole area drained into the lake (including the lake surface), allowing for a loss of 75 per cent. by evaporation, absorption, and the supply of natural plant growth. As the rainfall is from 16¼ to 66¾ inches per annum, it will be seen that the supply will always be sufficient to fill the lake every winter, and yield a large surplus. Although no surveys have been made by this department of the lake and its outlet to ascertain the feasibility of this plan, it is understood that there are no great engineering difficulties in the way of carrying out the work substantially as outlined.

Diversion of Cache Creek floods.

Referring to Part Two of this report, at page 39 and succeeding pages, it will be seen that I have spoken of the desirability and feasibility of diverting the flood waters of Cache and Putah Creeks into a channel to start high on their courses, and, running on a grade of two to three feet per mile, end in the Montezuma Slough north of Suisun Bay. The proposition here made to utilize the waters of Cache Creek more extensively for irrigation, is in complete harmony with the ideas advanced in connection with the drainage problem. Increasing the holding capacity of Clear Lake—which is on the uppermost tributary of the main stream—will diminish the flood volume below without danger of increasing it at any time, unless there is another reservoir constructed on the other large tributary of the main stream, as explained in the drainage report.

Increasing the holding capacity of the lake will not result in the flooding of lands not now overflowed at high water, for the surface would not be permitted to rise higher than it does now; only the water would be held in longer during the spring, and would be drawn

down lower towards the fall, and consequently would present a greater reservoir to be filled by the rains of the succeeding winter.

The construction of the canal of diversion proposed would be really the construction of a main irrigation channel, from which distributing ditches could be taken out every few miles for the watering of the plains below its line all the way to the Montezuma Hills.

IRRIGATION FROM MINING DITCHES.

Mining Ditches—History.

Throughout the mountains and foothills, from Mariposa to Shasta County, on the east side of the great valley scarcely a large stream is to be found from which there has not been a half dozen or more ditches constructed at some time since gold placers were discovered in California. The first decade of this exciting thirty-two years witnessed the building of hundreds of small ditches from the side cañons and larger tributary streams of the main rivers. The next ten years period saw the extension and enlargement of many of these, and the tapping of the main rivers themselves to a greater extent; and then it saw, too, almost the abandonment of many of the works, as the mines gave out. But in the meantime some prospered, and others did not; consolidation of interests were made—by the better to do owners buying out those anxious to sell—until sometimes many smal water right interests were merged into one. It was generally the owners of the larger canals that bought out others, and thus have grown up the big mining ditch properties, of which there are from one to a half dozen in the basin of every large stream from the Tuolumne to the Feather River.

The large ditches.

The main ditches, tapping the larger mountain torrents, carry from 2,000 to 4,000 miners' inches (50 to 125 cubic feet per second), on grades of four to twelve feet per mile, and at mean velocities of three to six feet per second. They are from five to eight feet in width on the bottom, have side slopes generally averaging one on one, and carry water two to four feet in depth. Some of these canals head far up in the mountains, 5,000 or even 6,000 feet above the level of the sea, in the deep cañon of some upper river, or at the site of some mountain valley—made to serve as a reservoir by a great dam thrown across its outlet gorge—and conduct their waters out upon the rugged spurs of the Sierras, which protrude westward between the mountain basins of the principal streams. Thence, dropped from higher level to lower, and conducted around points, along hillsides, over divides and in iron pipes across deep gulches, these ditch waters are brought to the mining grounds, sometimes 50 miles, and often 30 miles from their point of derivation.

Cost of large ditches.

The world probably does not present elsewhere an example of canal building where so many large works, constructed through such rugged country, may be found within an equal scope of territory. And when it is remembered that these ditches were many of them built when labor was four to six, and even eight dollars per day, it may well be understood that the aggregate cost of them runs up into the millions

of dollars. For some of the more modern built works, constructed with all the advantages of cheaper labor and experience in location and construction, have ranged in cost from 300,000 to 450,000 dollars, and we thus credit the assertions which are made to the effect that the construction of a few of the larger ditches in early times was accomplished only at expenditures of nearly a million apiece.

Mining Ditches and Irrigation.

These great works will become a rich heritage to irrigation. Already many of them deliver a part of their waters for this purpose, and in a number of instances a market is thus afforded for fully half the supply brought by them; while in a few cases, almost the entire flow is in this way, devoted to deriving another harvest than gold dust, from the hillsides and mountain plateaus. Generally speaking, it is the lower canals—those diverting waters from the streams at points but 1,500 to 2,500 feet above the level of the sea—which formerly supplied the foothill placer mines, whose flow now is used in irrigation, because the surface gold deposits for the working of which they were built, have been washed out, and opportunities are not afforded with but three or four exceptions for turning their streams upon great banks of auriferous gravel, as in the case of most of the ditches situated at greater elevations on the mountains.

The future of the large ditches.

But the time will come, and perhaps it is not far in the future (for events are seemingly training for the discouragement of hydraulic mining), when the larger monuments of the miners' enterprise, the ditches which are higher in the mountains, with their great dams and reservoirs, and which deliver their supply at points below 4,000 feet of elevation, will turn towards irrigation for their support. It is no argument to say that there are now works of the kind whose waters cannot find consumers; and furthermore, the result will not be charged by asserting now that it will never pay to keep up these great works in the high mountains (where their maintenance is a matter of considerable expense), for irrigation purposes. Present circumstances, to be sure, are unfavorable to irrigation through the mining counties, but they will change as the necessities of the case become apparent.

The irrigation of the future.

There are no irrigators, no people raised to train the vine, prune the tree, and guide the stream between the rows. A number, to be sure, are now thus occupied, but very few understood anything of the business when they invested their capital in it, and generally they had no previous experience here to guide them. Thus the proprietors of to-day are experimenting, and when the time comes, the younger people will look more to steady pursuits, and will profit by the practice now being had in irrigation throughout the foothills and communities of real irrigators, horticulturists, and agriculturists, will grow up.

Present use of water.

The use of water as it is frequently, at least, applied in the region now under consideration, cannot be taken as a standard by which to

judge of its future duty and consequent value in irrigation. As there are but few real irrigators, so are there only a limited number who understand the conservation of the water supply, and have any idea of how much land should be irrigated by a given quantity of water. In the manner now practiced the irrigation throughout the mountain and foothill counties, so far as it has come under my observation (and I have seen very much of it), is even more wasteful of water than where prevalent upon the plains; and in some cases the loss is very great and productive of harm. The crops are injured by too much irrigation, and neighborhoods formerly noted for their salubrious climate have been rendered unhealthful in a marked degree, not only by the accumulation of water in the low ravines and flat places on the hillsides and in the valleys, but by the saturation of the soils irrigated.

Use of muddy water.

A number of the canals delivering water for irrigation in these regions derive their supply from streams below where hydraulic mining is practiced, and their waters being very muddy, leave a considerable deposit upon the ground irrigated, and make marshes in the holes and hollows in which they settle elsewhere. It is a belief met with that the unhealthful effects of irrigation where this water is used is due to some peculiarity of the mud which is in it. There is no necessity for attributing any peculiar characteristics to the mud, nor even resting the odium upon it at all. Irrigation, wherever water is permitted to rest upon the ground, or continually run over its surface and soak away, becomes unhealthful; most of all is this so where the soil is rententive of moisture and the subsoil impervious.

Effects of Bad Drainage.

Even by the use of the purest water this result follows. There can be no more limpid stream than Kings River, yet the use of its waters upon the plains, near the foothills, has rendered the Town of Centerville and its neighborhood one of the most unhealthy spots in the State. Malarious fevers prevail there all the time, and at certain seasons nearly everybody has chills. Now, this is not attributable to mud in the water, for there is none. The facts are that, because the soil is very slow to receive water, a small stream is frequently allowed to run continually through an orchard, garden, or vineyard, to spread into the hollows or stand in side ditches for days at a time, and the ground becomes thoroughly saturated; the soil is retentive of moisture and the subsoil (near the surface) is impervious; no pains whatever is taken to cut drains to lead away surplus water nor to stop the supply often when the ground becomes flooded, as long as there is an escape somewhere into a low spot. The result is that these low spots become marshes and produce disease. The canals and ditches, too, are in some instances of exceedingly poor construction, their waters spread in shallow pools, and swamp plants flourish therein, so that the carelessness of the irrigators is well supported by the improvidence of the canal owners, and a full harvest of malaria results. Out upon the plains, in the neighborhood of the Town of Fresno, where the soil is deep and good natural drainage now exists, such results are not to be noticed.

Malaria along the foothills.

Thus it is that all along the foothills, where the streams emerge from the mountains and irrigation is practiced, malarious fevers are prevalent in a greater or less degree, and, seeing that the character of soils and subsoils is generally of the retentive and impervious character described as existing at Centerville, it is reasonable to conclude that the cause is to be recognized, as it is there, in the deficient drainage and careless use of the water, which is to be observed, and therefore the use of water in irrigating is not necessarily deleterious to health because it is muddy, or because of some peculiarity of the sediments it contains, and those who use such water will probably find the healthfulness of their neighborhood restored when only enough is used to bring forward the plant growth and no more, when the ground is kept well cultivated and the water is not allowed to stand in neighboring ditches or waste into adjacent depressions.

Abandoned distributing reservoirs.

Near many old mining camps where irrigation is now practiced there formerly existed numbers of small, shallow reservoirs, formed by the erection of little embankments, which would hold water back upon a half acre or more of land. In many instances these reservoirs have become filled with sediment and abandoned, and they may be seen now in the form of marshes, overgrown with swamp vegetation, and supplied with water, from some neighboring leaky ditch or ravine, from an irrigated tract near by. These are sufficient of themselves, in a number of instances noticed, to produce the change in the health of communities spoken of, and irrigation need not be held responsible for it at all.

Muddy water beneficial.

The presence of sands and sediments in water for irrigation is found to be beneficial rather than otherwise upon most soils of the valley, except where it is applied to the stems of very young plants, thereby checking their growth, or when grasses, clover, and alfalfa are deeply flooded, thus covering them with sediment, so that animals dislike the hay made therefrom. There are large tracts of land at a number of points along the foothills of the Sierras which are now fertile and productive, but which a few years ago were almost barren. The sediments in the water used for their irrigation have been retained upon the surface, and have made good soil. This is notably the case in the neighborhood of Folsom, and also near Smartsville, but such instances are to be found wherever irrigation from the lower mining ditches is practiced.

Wasteful Irrigation.

The extent to which irrigation is practiced from mining ditches is difficult of determination, for the tracts watered are generally small, of irregular shape, and much scattered, so that, their acreage being unknown, a rude measuring of them would be necessary, and I have not felt justified in attempting to do so in the infancy of this investigation. It is certain, however, that the duty of water attained is very small, for the practice of irrigating without proper preparation of the ground is observed almost everywhere; and but little attention is

paid to guidance of the water and saving the surplus. This is particularly the case where water is sold from the upper ditches—when the irrigator is probably a miner, who, having a clover patch at his home on the hillside, turns a small "head," or stream of water, into his ditch in the morning, whence it finds its way down the slope during the day, while the proprietor is away at his work, until evening, when it is changed to some other part of the little field; and this operation is repeated until the whole area is "wetted up."

Duty of water.

This is a very wasteful system, and, while at places where irrigation is practiced by those who made fruit raising, gardening, or small farming a business, more care is taken, it is more than probable that the area irrigated does not exceed 25 to 30 acres per cubic foot per second of water flowing for the irrigating season, which is generally four to five months in length. One must remember, in this connection, that this irrigation is in a country where there are abundant rains during winter, and it is only practiced during spring and summer, and hence the duty of the water should be higher than on the southern plains where irrigation takes the place of winter rains, as well as supplies the summer moisture. And furthermore, the crops cultivated through the mining counties by irrigation are not of the kinds that require as copious watering as the grain, corn, and alfalfa of the valley plains; and still again, the loss of water is very small generally from the mountain ditches, whereas on the plains it is an important item.

Extent of irrigation—mining counties.

According to information and data collected, it is probable that about 300 cubic feet per second (12,000 miners' inches) of water are used daily in irrigation during the summer months in the mountains and foothills on the western slope of the Sierras, from Tuolumne to Butte County, inclusive, but exclusive of Sierra and Plumas Counties (of which nothing is known in this connection). Placing the duty at 30 acres per cubic foot per second, the area irrigated would be 9,000 acres. This irrigation is for the most part in very small tracts, many of them less than an acre in area, and few exceeding 50 acres. They are generally cultivated in barley, clover, small fruits, orchards, vineyards, and vegetables; and now oranges, lemons, limes, and walnuts are being extensively planted.

EXTENT OF IRRIGATION IN CALIFORNIA.

The outlook of irrigation.

Summarizing the general facts stated in the foregoing pages, descriptive of that portion of the irrigated area of California which has thus far been examined by this Department, we see that the progress made, although small as compared with what may be expected in the future, is considerable. Irrigation may be said to be fairly introduced in the sections of the State most requiring its aid. Its necessity is now more fully and generally recognized than ever before, and however discouraging and costly may have been the lessons learned from experience in some localities in the past, the advance has been constant, not only in the extent over which it has been practiced, but in that knowledge of the methods which is so essential in adapting it to the

varied conditions to be met with. Great strides have been taken within the past ten years, and the next decade should witness a still more rapid development of this agriculture, and its extension over a territory widely surpassing that which has already been improved, fertilized, and reclaimed by it.

Recapitulation.

Briefly recapitulating the works and extent of irrigation described, we find that:

In Los Angeles and San Bernardino Counties the area irrigated from streams, springs, and artesian wells is about 82,485 acres; the number of independent works of irrigation, 135 to 140; the number of artesian wells, the majority of which are used for irrigation, 950 to 1,000.

The crops irrigated are largely orchards of deciduous and semi-tropical fruits and vineyards, corn, potatoes, and other field crops, except cereals.

In Kern County the area irrigated from Kern River is about 38,800 acres; the number of canals and ditches constructed, 32; their aggregate length, about 275 miles; character of crops irrigated, alfalfa, cereals, corn, potatoes, beans, and others of that class.

In Tulare and Fresno Counties the area irrigated from Tule River varies with the water supply and the seasons, the greatest extent of land thus watered having been 4,000 to 4,500 acres; the canals and ditches are 12 in number.

From the Kaweah River the area irrigated is variable in extent, the greatest area ever watered having been about 22,000 acres. The canals and ditches are 14 in number.

From Kings River the area irrigated is 61,210 acres; the canals number 15, all told.

From Fresno River the greatest area of land thus far irrigated is about 3,000 acres from one canal. In all these sections the crops irrigated are similar to those of Kern County; cereals, alfalfa, and corn predominating in importance.

From the San Joaquin River the greatest area that has been irrigated is about 52,000 acres, of which about one-third was wild grass land, one-fourth alfalfa, and the remainder chiefly cereals. The canals completed are 2 in number, besides 2 natural channels used for the purpose.

From the Chowchilla, Mariposa, and Bear Creeks, all intermittent streams, irrigation is practiced in the foothills and upon the plains to a limited extent, when water is available.

From the Merced River one large canal and a number of small farm ditches have been constructed, irrigating thus far 1,500 to 2,000 acres.

From the Tuolumne River no irrigation has yet been practiced upon the plains, but upon the bottom lands near the foothills a small area devoted to gardens is watered by two ditches.

From the Stanislaus River irrigation is as yet confined to vineyards and gardens in the vicinity of Knight's Ferry, supplied by three ditches.

From the Calaveras River the greatest area irrigated in any one season is estimated at 3,000 to 5,000 acres, confined exclusively to cereals.

The total irrigated area of the San Joaquin Valley plains may be safely estimated at 188,000 acres.

I have estimated the area of lands irrigated in the foothill counties, from Tuolumne to Butte, at 9,000 acres, but of course this is a statement not based upon full information.

The lands irrigated from Cache Creek by means of three canals, aggregate about 13,400 acres.

It will be seen that the total area of lands cultivated by irrigation prior to the present season of 1880, in the districts spoken of, is 292,885 acres, viz.: San Bernardino and Los Angeles, 82,485 acres; San Joaquin Valley plains, 188,000 acres; Sacramento Valley (Cache Creek,) 13,400 acres. In the foothill counties east of Sacramento and San Joaquin Valley, 9,000 acres. I have no means of estimating the extent of irrigation in other quarters.

IRRIGATION FROM VARIOUS SOURCES.

The examinations made.

The examinations of this Department in the line of irrigation have, thus far, been almost exclusively confined to the Counties of San Bernardino, Los Angeles, Kern, Tulare, Fresno, Merced, and Yolo. In the four counties named, and lying in the San Joaquin Valley, the examinations and surveys have been more thorough than elsewhere. The rivers and canals have been carefully gauged and their total discharge computed for the irrigating season of 1879. In other localities but little more than a general reconnoissance was attempted, in which the assistants assigned to that duty familiarized themselves with the existing works, studied the practice of irrigation peculiar to each section, obtained statistics as to the extent and character of the irrigated lands, and acquired such detailed information as was available and essential in forming general conclusions on the subject. And what has been said, and what will be found in the Appendices hereto, is the result of this work, together with my own observations and familiarity with the subject.

Other irrigation regions.

The fact has not been overlooked that there are other large and important districts in the State, where irrigation is practiced, having equal claims to consideration by this Department, but the means and the time have, as yet, been inadequate to the extension of the investigation beyond its present limit. Among the more important of these outlying districts may be mentioned the Valley of Owen's River, in Inyo County, where there are several hundred thousand acres of irrigable land, and a considerable area already irrigated; Salinas Valley, on the coast, where a system of irrigation works is very much required; Trinity Valley, in the extreme northern part of the State, where irrigation is largely practiced; and the mountain valleys of Plumas, Lassen, and Shasta Counties, where no small amount of progress has already been made in the artificial use of water. In San Diego, Ventura, and Santa Barbara Counties, irrigation, although not extensively developed as yet, is of considerable importance; while in the Valley of Russian River, in Sonoma County, there is a large field for development in that direction, although the rainfall there is generally so abundant as to preclude the *necessity* for the artificial watering of cereals and other early crops.

On the southeastern frontier of the State, too, there flows a river—the Colorado—greater than any within her borders, and adjacent to it a vast body of arable land, only requiring the application of water to become fertile and populous. It will be seen at a glance how great is the field yet to be examined before even a superficial knowledge of the whole subject of irrigation, under the varied conditions which modify its practice in different localities of this State, can be acquired.

What has been learned.

To treat the question in the most satisfactory way it would, of course, be desirable to have complete information concerning the present state of development in all those localities where irrigation is likely to assume considerable importance in the future, and to know the circumstances which may distinguish each particular section from all others, but in the limited time since the organization of this Department so exhaustive a study of the subject could not be expected. Enough is already known, however, of the more striking and prominent impediments in the way of future progress to form a basis for the suggestion of remedies for leading defects, which have grown up with the development of the system in California, and to prescribe general measures that cannot but be beneficial to all localities.

CHAPTER III.

THE DUTY OF WATER AND THE WATER SUPPLY IN CALIFORNIA.

The Irrigation Duty of Water.

Definition of the "duty of water."

The extent of the duty of water may be expressed by an announcement of the quantity required to irrigate a superficial area of land of standard dimensions—as, for instance, an acre or a *hectare;* or, by a statement of the area of land effectually irrigated by the use of a definite volume of water, delivered at an uniform rate throughout a certain period of time—the irrigation season. But, whether the idea is conveyed in terms of the measure of service to be performed on the standard area of land, by water, in order to accomplish its irrigation, or in terms of the extent of land which the standard volume of water, flowing continuously, as explained, will effectually serve in irrigation, the term "*duty of water*" still relates to the ratio between the numerical expression (in standard measure) for the volume of water used, and a like expression for the area of land irrigated in one irrigation season.

Illustration of the definition.

Thus, in the case of a stream which delivers water at the rate of five cubic feet per second through the season, and accomplishes the irrigation of 500 acres of land, we say that the water performs a *duty of 100 acres per second-foot;* meaning that each foot per second, continuously flowing through the season, irrigates one hundred acres of land. This expression is, of course, in terms of the extent of duty in acreage performed by the standard volume of water—the cubic foot per second of continuous flow for the season.

On the other hand, we might say, in the case cited for illustration, that the duty performed was *one-hundredth of a cubic foot per second to the acre*, and the meaning would, of course, be the same, but the expression would be one implying a variable volume of water to a standard area of land.

A recent Spanish authority.

Professor Andres Llaurado, in his *Tratado de Aquas y Riegos*, published in Madrid, in 1878, adopts the latter mode of defining the duty of water. He says the idea of the volume necessary to effect the irrigation of the standard area (whatever it may be, whether an acre or a hectare) of land, may be expressed in three ways, as follows:

First—In the form of a continuous flow, expressed by a number of litres (or cubic feet, as it would be expressed by English engineers) in the unit of time.

Second—By a layer of water of a certain height extending over the surface.

Third—By a determined number of cubic metres of water per hectare (or cubic feet per acre).

The author then says in explanation:

In the first shape, which is that generally adopted in relations between the government and irrigation grantees, one may at once deduce the number of hectares irrigable by a known discharge.

By the second, the results of an irrigation may be compared, at first sight, with those of a rainfall corresponding to a determined height indicated by the rain gauge.

And the third form of representation of the volume allows us to calculate, without further measure, the number of hectares irrigable with the waters of a reservoir of known capacity.

Importance of this subject.

In projecting works for the irrigation of any particular district, the first consideration must be the volume of water supply available; the second, the duty which that water can reasonably be expected to accomplish; or, in other words, the allowance that must be made to each acre of land to be irrigated. The determination of these points furnishes the basis for calculating the proper dimensions and capacity to be given to the works. In the case of existing canals, it is essential to know within some reasonable limits the area which each may be presumed to irrigate, if we are to determine the question as to whether they are or are not adequate to the watering of the lands they command. And this is to be ascertained by measurement of their capacity, and assigning a reasonable duty to the water carried by them.

The duty of water in the future.

That the ultimate duty of water can be preliminarily determined upon in any case is not in the nature of things possible. As a general thing the duty of water is increasing in most sections of the State, as the soils become saturated by repeated wetting and are brought into a more tractable condition. Long cultivation, improved methods of preparing land, and increasing skill in the application of water, all have a tendency to lessen the amount necessary to the growth of crops. The extent to which this tendency may reach is dependent too upon other influences, among which is the volume of supply available; for we see that a scarcity of water often leads to the adoption of such extreme measures of economy as to increase its duty beyond all expectation. But presuming that careful observation had given sufficient data for calculating the present and probable ultimate duty of water in each section for cereals, alfalfa, orchards, and other crops now most generally produced in California, the calculation would be at fault if a change in the types of agriculture should be brought about. Suppose, for example, that rice culture should be introduced, the duty of water would be at once changed and materially diminished; or, if any considerable proportion of our irrigated wheat fields should be transformed into orchards and vineyards, we could look for a great change of water duty in the opposite direction.

Water must be economized.

Unfortunately, in the portions of the State where irrigation is indispensable, it appears from present data that it will be necessary to exercise all the care and vigilance possible in the conservation and use of the water supply in order to bring under irrigation nearly all of the lands which demand its benefits.

A momentary contemplation of this state of affairs will bring about a forcible realization of the great importance of the present subject in hand—the duty of water.

To illustrate this whole matter, I now quote from the best authori-

ties on irrigation. In so doing it is not so much the intention to show how far behind those of other countries the results of irrigation are here, as to point out how much attention has been paid to the point in hand, wherever irrigation has been practiced, though often too late to remedy the evils of wasteful systems, in order that we may see how important it is for similar results to be guarded against here.

Duty of Water Abroad.

California irrigation may be more aptly compared with that of Spain than with that of any other country, because of the close resemblance in climate.

Duty of water in Spain.

Louis D'A. Jackson, in *Hydraulic Manual and Statistics* (London, 1875), gives the following data on Spanish irrigation compiled from that furnished by Geo. Higgin, C. E., concerning certain districts where, excepting Granada, the annual rainfall is from 11 to 22 inches:

WATER DUTY ON OLD WORKS.	Per cubic foot per second —acres.
In Valencia, from the Jucar Canal (rice)	35
In Valencia, from the Turia Canal	83
In Gandia (type of old irrigation)	88
In Murcia and Orihuela (old)	96
In Granada (old)	244
Esla and Henares (new)	157
Lowest duty in Spain generally (new)	140

The practice of watering usual in Valencia is, for lucerne (alfalfa), one watering in 8 or 10 days; for maize, beans, and hemp, one in 15 days; for potatoes, one in 21 days; for cereals, one in 30 days. The average amount given at one watering in ordinary soil is 500 cubic meters per hectare (7,060 cubic feet per acre), and the fullest ever given is 9,884 cubic feet per acre.

These amounts would give depths of two to two and three-quarters inches at each watering.

The same author quotes the data of Mr. Roberts, C. E., in 1867, from which it appears that in Valencia the average water duty is 280 acres per cubic foot per second; in Reoja, on low, clayey soil, 350 acres; in Murcia, Alicante, Aragon, and Cataluña, 70 acres. For cereals, and grasses generally, the average duty is placed at 280 acres; for huertas, or gardens, 95 acres; all other cultivations, 140 acres in ordinary seasons, or in extremely dry seasons 70 acres per cubic foot per second:

The practice of watering is, for cereals, etc., four to six waterings yearly; for meadows, eight; and for gardens, twenty; each watering being in practice two inches deep, and never exceeding two and three-quarter inches. The average number of waterings in a year given to land in Valencia is twelve.

Duty in India and Spain compared.

Lieut. C. C. Scott Moncrieff (*Irrigation in Southern Europe*, London, 1868), an engineer detailed by the Government of India to make an examination and report upon irrigation in France, Spain, and Italy, says:

I have nowhere seen in North India anything like the pains which in Europe is bestowed on collecting the water off the fields and applying it again. The want of slope in the country is

against this, and so it is usual to give much fewer waterings, but more at a time. For the wheat crop, which is grown in the cold season, and, therefore, at a considerably lower temperature than in Spain, four waterings are quite enough, and almost no other crop requires more except rice and sugar cane, which are sometimes irrigated as often as twelve times, and are watered by a rainy season as well. * * * * A safe mean in North India is to reckon five acres in twenty-four hours as the area to be watered by one cubic foot per second, where, as is general, the soil is light. We may further take fifty days as the greatest interval allowed to elapse between two waterings, and so we shall obtain $5\times50=250$ acres as the duty to be got out of each cubic foot per second, that is 0.28 litre per hectare, supposing it can be utilized at this rate all the year round, and this is not more than has been done more than once on the Eastern Jumna Canal. The discharge there is measured at the head of the canal, and the water probably runs on an average more than 300 miles before it actually reaches the field to be watered. It is usual to deduct about 20 per cent. for the loss by filtration, evaporation, etc., en route, and yet a duty as high as this has been proved attainable without making allowance for the deduction. Of these 250 acres, about 18 per cent. usually consists of rice, and as much more of sugar cane, each requiring a large amount of water; 50 per cent. of wheat and barley, and the rest of inferior crops, only watered once or twice. The rain, of which far the greater part falls in June, July, and August, consists of about 40 inches a year—more, certainly, than in Castile. The heat and consequent evaporation must also be considerably greater.

The author cites the foregoing example of water duty in North India to make a comparison with that of Spain, and concerning the latter goes on to say:

Article 10 of the Henares Canal concession lays down that each watering must consist of a depth of 2.75 inches; and this is founded, I believe, on experiments made by Señor Ribera, proving that 2.36 inches (0.06 metre) is an ample depth for a watering in Castile. With a sheet of 2.75 inches deep, a cubic foot per second waters 8½ acres per diem. And if, as in India, fifty days could be allowed to elapse between each watering, we should have a duty of 425 acres instead of 140 acres per cubic foot per second, which is all that is looked for in the Henares Canal, or estimated by Señor Ribera. He is practically borne out in this by the fact that in only one part of Spain is the duty higher, namely, in Lorca, in the province of Murcia, where over an area of 27,000 acres, 210 are irrigated per cubic foot. The cultivation, however, which is chiefly of cereals, does not receive water more than once or twice a year. * * * * I feel sanguine that after a few years, sound English habits of business in the economical distribution of the water, may increase the area and work up to a standard, perhaps not equal to ours in India, where we have such different conditions to deal with, but to something considerably higher than is now counted on.

Since this was written (1868) it would seem that some progress had been made in the way of increasing the duty of water, for, according to Higgin, the authority before quoted, in 1873, the average duty of the Henares Canal was estimated at 157 acres per second-foot.

Waste of water—Old water-rights.

As an instance of how old established water rights interfere with the accomplishment of the full duty to be expected of water, Moncrieff cites the Jucar Canal in Southern Spain, where 911 cubic feet per second irrigates only 50,000 acres—an average duty of 54.88 acres per cubic foot per second. He says:

The canal has gone on for years only irrigating the lands of twenty-one towns or villages, which have a right to share the water among them, laid down by law. Of course, then, these villages exercise no great economy. They have as much as they wish; and M. Aymard found the escapes open and some 200 cubic feet per second being returned to the river at one of the dryest seasons of the year, at the end of July. The irrigating villages, too, have arrived at their full extent of irrigation, for they annually water nearly the whole of their fields.

The low duty of water on the Jucar Canal is also partly accounted for from the fact that nearly one-half of the area irrigated is in rice, which here takes, according to different authorities, one cubic foot of water per second for each 28 to 35 acres.

Llaurado's experiments in Barcelona.

Prof. Andrés Llaurado, the most recent writer on the subject of irrigation in Spain, gives the results of some personal experiments in Barcelona, in garden irrigation, where the soil was a rich alluvion and underlaid by clay. Applications of water to a depth of 3.94 inches, sank in the soil to a depth of 9.84 inches, while on less friable soil divided by ditches 14 inches wide, and separated by ridges of equal width, an application equivalent to 4.72 inches in the depth, wetted the ground beneath the ditches 8.66 inches, leaving the crests of the ridges dry. From the mean of all his experiments he deduces conclusions which may be liberally rendered as follows:

For the months from January to May, inclusive, at a rate of four monthly irrigations, one cubic foot per second of continuous flow will irrigate 106 acres.

For June, July, and August, at a rate of 11 irrigations monthly, one cubic foot per second waters 38.7 acres.

For the remaining four months, at a rate of five irrigations monthly, one cubic foot per second waters 85.4 acres.

From these averages he concludes that a mean continuous flow of 1.09 litres per second, is sufficient for one hectare, or 64.2 acres per cubic foot per second.

In this case crops were constantly being taken off and replaced, so that two were always on the ground at once. The total number of irrigations per annum were 73, an average of one every five days, while the total depth applied was 11.27 feet, or 1.85 inches at each watering.

Llaurado's data on irrigation duty in Spain.

The same author gives the following data on the consumption of water in the principal agricultural zones of Spain.

On the banks of the River Ter, which waters the province of Gerona, the quantity of water dedicated to irrigation is equivalent to a continuous flow of 1.14 litres per second per hectare (61.4 acres per second-foot). The period of irrigation lasts from May to September, and the normal irrigation term is every ten or twelve days.

In the valley of the Besós, irrigated by the Moncada Canal, 500 litres are employed to irrigate 680 hectares, corresponding to 0.74 litre per superficial unit (94.6 acres per cubic foot per second).

On the Canals of Manresa, the Infanta, and the Derecha, derived from the River Llobregat, the normal type of continuous flow reaches one litre per second per hectare (70 acres per second-foot).

The Tauste and Imperial Canals, derived from the Ebro, yield the same result—one litre per second per hectare.

The eight lower ditches of the Turia irrigate 10,500 hectares, with a minimum volume of 11,250 litres, equivalent to 1.06 litres per hectare (66 acres per second-foot).

The Royal Canal of the Jucar (as gauged by the author) carries 26,381 litres per second, and irrigates 13,844 hectares—an average of nearly two litres per second per hectare (35 acres per cubic foot per second). It is to be noted, however, that nearly one-half of the irrigated area is devoted to rice fields, which require nearly 2.5 litres per hectare.

The canal of the City of Tátiva, whose discharge the author has also gauged, irrigates a garden zone (huerta) with 1.67 litres per second per hectare (equal to 41.9 acres per cubic foot per second).

The Canal of Meses, near Tátiva, with a volume of 614 litres, irrigates 256 hectares of rice, an average of 2.4 litres per second per hectare (29.2 acres per cubic foot per second).

Of the garden and orchard fields of Murcia, embracing a total area of 10,769 hectares, only 8,000 are irrigated by the *live waters* of the Segura, the remainder using the *dead waters* (or drainage waters) of the upper irrigated fields—the river having, in dry years, a discharge of but eight or nine cubic metres (282.5 to 317.8 cubic feet) per second, and great loss occurring in the elaborate network of canals and ditches from filtration and evaporation. The average duty of the water consumed is one litre per second per hectare (70 acres per second-foot).

In Lorca, 11,000 hectares are irrigated with a minimum discharge of 340 litres—the low water discharge of the Guadalantin River, from which it would appear that only 0.1 litre would be the continuous flow—altogether insufficient. The distribution of the cultivation in the district

explains, however, this apparent anomaly. The district is mostly devoted to the cultivation of winter cereals, which receive but two irrigations a year, and do without them when rains are abundant. The high price of water limits, in an extraordinary manner, the extension of summer crops, which are circumscribed to the sections of country enjoying free water.

The Genil River gives to the Royal Canal of Granada during low water stage two metres per second, with which 6,900 hectares are watered, an average of 0.29 litre per second per hectare (241.4 acres per second-foot), which would be insufficient for thorough cultivation all over the zone, but is explained by the fact that the greater part of the irrigated area is devoted to cereals which require no summer irrigation. The Genil is one of the few permanently fed rivers of Spain, as, when the rains stop, the melting snows keep it supplied.

Official standards adopted.

The French administration adopts, in irrigation water grants, the standard allotment of one litre per second per hectare; in Spain the Government generally adopts the standard of half a litre per second per hectare, (140 acres per second-foot.)

Waterings given to various crops in Spain.

Before taking leave of the subject of water duty in Spain, which it will be noted is extremely variable, and ranges from 25 to 350 acres per cubic foot per second of continuous flow during the season of irrigation, it will be interesting to add from the same author last quoted, certain data on the number and duration of the irrigations bestowed on various crops. He says:

The number of waterings needed by different crops are subject to undetermined influences, similar to those formulated when establishing the problem of water quantity required by the unity of surface. Under equal circumstances differences may occur in the number of irrigations assignable to a continuous cultivation from the effect of distributing a uniform volume of water in periods of different duration.

Rice—Rice fields require water during three months of the year, that is, from the 15th of May, when transplantation takes place, till the middle or end of August. The watering is continuous and by overflow, the beds being covered with water seven to eight centimetres deep. The consumption of water is 2.40 litres per second per hectare (equal to 25 acres per second-foot), according to experiments made by the author in the Jucar rice fields.

Wheat requires but little water. In the Valencian fields they irrigate before sowing; the crop is irrigated in March, again in April, and generally again at the beginning of June. With but slight differences, the method is the same in Cataluña, Aragon, Murcia, and Granada.

Barley—In Granada, barley is only irrigated once, in April.

Maize or Indian Corn—In Valencia corn is commonly planted from June 15th to 25th. In fallowed land it is planted in May. During its growth, till the end of September, or middle of October, it receives eight waterings. According to M. Aymard, corn in Algeria is irrigated every ten or fifteen days, and the volume of water assigned is equivalent to a constant flow of 0.26 to 0.60 litres per second per hectare (116.6 to 270 acres per cubic foot per second).

Alfalfa—During the hot months alfalfa requires watering every eight days, and every fifteen days during the remainder of the year in the absence of rain, or thirty-one irrigations in all. In Alcira it is cut twelve times; in other less favored localities of the Valencian fields, seven to five times per annum. On the banks of the Ter it only allows of five cuttings, and is commonly irrigated ten times in a year.

Carrots and other annual fodder plants in the fields of Valencia are sown broadcast from the twenty-fourth of June to the fifteenth of August. Shortly after they are irrigated, and within the space of fifteen days, they are irrigated three times, and afterwards three times again at intervals of ten days. During their growth they receive in all eight waterings, and are gathered in February or March of the following year.

The Orange—It is well known that the orange prospers in lands fertile and porous, where the water penetrates easily without ever forming pools or pockets. It thrives to perfection in the sandy loams of Orihuela, in the sandy, silicious, calcareous, ferruginous soils of Alcira and Carcagente, and in the granitic sands of Canet, and other localities on the coast of Barcelona, when sufficient manure is added. Compact clay is unfit for its cultivation; frost kills the trees, and they sicken with too little or to much water. In the fields of Alcira and Carcagente from April to October the orange orchards are irrigated every eight days. According to Señor Cavanilles, in the fields of Orihuela, and lands of the same class, orange orchards should be irrigated every twenty days from February to November, and never during the winter, unless the season be extraordinarily dry.

The notable difference observed in the number of irrigations given to the same cultivation in Alcira and in Orihuela depends principally upon the greater or less volume of water applied at each irrigation; in the former locality the orchards are irrigated by means of water flowing in continuous streams; in the latter the supply is derived from wells. Doubtless the nature of the subsoil contributes also to produce the difference, for in Orihuela the subsoil is impermeable, for which reason the land preserves its moisture longer than in the friable, porous soils that constitute the substratum of the orange orchards of Alcira.

Irrigation duty in France.

In Jackson's *Hydraulic Manual and Statistics*, is quoted certain data with reference to irrigation in France, from which it appears that in Dauphine, on the Marseilles Canal, only one watering per week, of a depth of 1.18 inches (three centimetres) is given on heavy lands; but on light soil, and with the object of making up for loss by filtration, the depth allowed is ten centimetres (3.94 inches). In lower Languedoc and Rousillon, the same practice of watering once a week is in vogue, but with a depth of 1.97 inches on heavy, and 3.94 inches on light land; in the Camtale of Province the same quantity is used as in Rousillon for field crops, but a greater quantity for garden crops. There are, however, localities in Languedoc and Provence, where this system is practiced only during one or two months, or for two or three times in the year. From the Canal St. Julian, on the Durance, at Cavaillon, Vaucluse, the depth applied per week is estimated at fifteen centimetres (5.91 inches).

Count Gasparin, De Cossigny, and other French authorities agree that in the climate of Provence, where irrigation is practiced from April 1st to October 1st, the watering usually given is three to four inches, once in ten or twelve days.

M. Pareto cites some examples in which water performs a duty exceeding 280 acres per second-foot; while M. Hervi Mangon found, from a number of experiments in the Department of Vaucluse, that the volume required to irrigate a hectare varied from one to four litres per second; that is to say, the duty ranged from 17½ to 70 acres per second-foot.

These great variations are to be accounted for by differences in crops, in soils, and in climate; and they are also controlled in still greater degree by the extent of water supply and the intelligence of the irrigator in the economical application of water.

Effect of onerous concessions of water in France.

From a paper of Mr. George Wilson, member of the Institute of Civil Engineers, on irrigation in the south of France, Department of Bouches du Rhone, it appears that the average duty of water in that section over a period of six months, is but one hectare per litre per second (70 acres per second-foot), during a period of six months. This would be equiavlent to a layer 62¼ inches deep on the land. These figures are supported by many different authorities, and may be accepted as applying to nearly all the irrigated territory in the south of France. Wilson shows very clearly that this low duty is caused by the abuse of water privileges, made possible by the existence of the old water rights acquired many years ago, which give individual landowners the control of so much more water than they require that no care is taken to economize it, and great quantities are wasted. He says:

> The old canals cannot be administered in a manner fully to develop their resources, in consequence of the conflicting interests of the various owners or persons interested in them, by virtue of the onerous concessions of former days.

The water in some instances has to be supplied in unlimited quantity to land whose owners formerly bought the right for allowing the canals to be built through their property, and to others who bought the right to use the water at a very low price. The result is that the annual revenue is barely sufficient to maintain the canals

and works. Consequently, the water is not only wasted by the irrigators, but the works are suffered to get out of repair, and water is lost from them.

In the instance of the Craponne Canal, the projector ruined himself in carrying out the works, as he met with such violent opposition from the landed proprietors to the construction of the canal through their property, that he had to grant concessions for the use of water at very low prices to remove their objections. These concessions have given rise to continual litigation and trouble in the administration of the canal, and have been a constant hindrance to the development and progress of irrigation.

Similar causes have affected irrigation duty in Piedmont and Lombardy, Italy, where the right to water was acquired through royal concessions by the owners of large estates during the troubled times of the past, and it has since been found impossible to regulate the use and prevent waste of the precious element where such privileges are held.

Irrigation duty in Italy.

The average duty of water in Piedmont and Lombardy, where small grain requires no irrigation, is given by various authorities at about 80 acres per second-foot on old works, and 110 acres on the most modern canals. These figures are given as averages. No specific data as to the number and volume of the waterings given to the various crops can be quoted, but here, as in Spain, the low duty of water is the subject of much criticism by English engineers familiar with the more economical methods of irrigation practiced in India.

In this connection it should be remembered that a considerable portion of the irrigation in Italy is of the meadows, which require almost a constant sheet of water running over them, and of rice, which is kept submerged for several months of its growth.

Irrigation duty in India.

In the foregoing pages it will be observed that Moncrieff estimates the maximum irrigation duty of the Eastern Jumna Canal at 250 acres per second-foot. There are few other engineers who place the duty of water so high in any part of India.

J. S. Beresford, C. E., estimates the duty in the same locality at 160 to 180 acres per second-foot.

The average of a number of experiments in watering wheat and rice on the Bari Doab Canal, Northwest Province, by E. C. Palmer, C. E., in 1871, show that an average depth 0.24 feet (3 inches nearly), on the whole surface gives a thorough watering to the average soil of the district; sandy soils require 0.31 feet.

Wheat in a dry season requires five waterings; the first for preparing the land for ploughing, the others during the season of growth, the total depth applied in all the irrigations being equivalent to 0.95 feet. Rice requires ten floodings, the total quantity applied being 326,700 cubic feet, a mean depth for the season of 7.4 feet.

Irrigation duty in Algeria, Africa.

The system of irrigation practiced in Algeria is copied from that of Spain, the climatic condition, the régime of watercourses, and the nature of the crops cultivated in both countries being about the same. Irrigation works there have been constructed by the French Govern-

ment and turned over to the irrigators, who are organized in irrigation districts, but in all cases the land and the water are inseparably united—the land may not be sold without at the same time selling its right to water. Thus the irrigated districts, the main canals, and the network of distributing ditches, form an unvarying whole which cannot be subject to any modification without an entire revision of the statutes of the irrigation districts. In general it may be said that no crops can be raised in Algeria without irrigation, in which particular it corresponds with the conditions found in the upper San Joaquin Valley. This fact explains the high value placed upon water and the economy displayed in its use.

From a special paper, published in the *Annales des Ponts et Chaussées*, on Algerian irrigation, it appears that cultivation in the Habra Valley is divided into two general classes: winter crops, consisting of wheat, barley, oats, and hay, which receive two or three waterings in the seven months, from November to May, inclusive; and summer crops of cotton, corn, and flax, which are given ten irrigations in the period from May to September, inclusive. The depth of water applied to winter crops at each watering is about four inches, the total depth nearly one foot, and the average irrigation duty 420 acres per second-foot, while for summer crops 2½ inches is supplied at each irrigation, the total depth given in the season is 25.2 inches, and the average duty 140 acres per cubic foot per second of continuous flow.

Irrigation duty in Utah.

In the valuable report of Major J. W. Powell, geologist in charge of the United States Geographical and Geological Survey of the Rocky Mountain region, on the "Lands of the arid region," published in 1879, are given some interesting data on the duty of water in Utah, where irrigation has been practiced for about thirty years, and an aggregate area of 325,000 acres brought under cultivation thereby. Mr. G. K. Gilbert, to whom was assigned the study of the irrigation system of the Salt Lake Basin, writes:

> By comparing the volumes of certain streams in Utah, that are now used in irrigation to their full capacity, with the quantities of land that they serve, I have found that 100 acres of dry bench land, (*i. e.* land with a deep, dry, open subsoil) will not yield a full crop of grain with less than one cubic foot of water per second, and this under the most favorable climate of the Territory. Where the climate is drier, a greater quantity is required. Where there is a moist subsoil, a less may suffice.

Regarding the seasons of irrigation, he writes:

> In the low valleys the irrigation of wheat and other small grains begins about the first of June, and continues until the latter part of July. The irrigation of corn and potatoes begins in the early part of July, and continues until the middle of August. In the middle of July all the land calls for water, and if the supply is sufficient at that time, it is sure to meet all demands at other times. It will be convenient to call that time the *critical season*. In the higher agricultural valleys corn and potatoes are not grown, but the irrigation of small grains and hay is carried on from the middle of June to the middle or latter part of August. Through all this time the volume of the streams is diminishing, and if they fail at all, it is at the end of the season. The critical season for the higher valleys, is about the middle of August.

It will be seen that the irrigation period is limited to about three months—a very short time, if the crops need watering at frequent intervals. In California, where irrigation of cereals may be advantageously practised for seven months, the irrigation duty of water should naturally exceed that attainable in Utah.

Captain C. E. Dutton, who conducted the examination of the Sevier

Valley, Utah, the climate of which is even less humid than that of the Salt Lake Valley, estimates the duty of water on new lands at about 40 acres per second-foot, and considers that 80 acres is the best that can be hoped for on old lands from the same unit of water. He says: "Probably there are few regions in the world were the demand of the soil for water is so great as here where the supply is so small."

The mean annual precipitation in the Salt Lake Valley, as observed over a period of ten years, is given in the report at 18.82 inches, distributed as follows: Spring, 7.20; summer, 2.18; autumn, 3.24; winter, 6.20. This was from observations at Camp Douglas, while at Salt Lake City, adjacent to the fort, but at a lower elevation, the mean precipitation for nine years is given at 24.81 inches. At other points in southern Utah, the mean annual rainfall is given as follows: Harrisburg, 13.74 inches; St. George, 11.39 inches; Camp Floyd, 7.33 inches.

A Comparison of Water Duties.

A comparison of all these examples of water duty in other countries where irrigation has become systemized in a greater degree, with the results thus far attained in California, is highly instructive. But before making this study, it is necessary to point out one natural cause of variation in the statements given by different authorities on the duty of water, for it is one that should constantly be borne in mind in drawing conclusions. Many writers estimate the duty of water on the basis of the total quantity flowing in the canals at their intake, without making any allowance for loss by filtration and evaporation in transit to the lands to be irrigated; that is to say, knowing the mean discharge of the canals and the total number of acres irrigated by each, by dividing the one into the other they arrive at the average area watered by each cubic foot per second of mean flow. On the other hand, other authorities state the results of experiments on water duty from measurements taken immediately at the fields irrigated, and having thus ascertained the depth actually applied at each watering, and the intervals between applications, estimate the average duty of the second-foot of continuous flow. The one may be called the *gross duty*, the other the *net duty* of water. If the water is carried long distances over porous soils, the loss before it is used is very considerable, and the variation between the gross and net duty great.

A study of water duty.

In making a study of any irrigation works it is essential to the engineer that he should ascertain both the gross and the net duty of water. If there be great disparity between the two there exists some radical defect in the system which needs to be remedied. To estimate the effective duty of a river in irrigation it is necessary to make allowance for unavoidable loss, and therefore we take the gross duty of water into our calculation.

Duty of Water—California Experience.

In the observations made by this department the gross duty was obtained with considerable accuracy in many sections by gaugings of the canals during the season of irrigation. Where this was not practicable special inquiry and experiment gave approximately the net duty peculiar to the different sections examined.

Irrigation duty from Kern River.

On page 81, Appendix B, will be found a table wherein the gross and probable net duty of water from the various canals derived from Kern River, for the first seven months of the past year, are set forth; and on pages 86 to 90 of the same Appendix are a number of examples illustrating the great variation in net duty under different conditions. Taking the average of all the crops irrigated—principally wheat, barley, alfalfa, and corn—the gross duty is seen by the table to range from 28 to 112 acres per second-foot (throwing out exceptionally extreme cases), and the probable net duty at the same time averaging from 48 to 150 acres per second-foot. The gross duty for all the water diverted for irrigation was about 70 acres per second-foot. This, it will be observed, was for the season from January to July inclusive. No measurements were taken of water used on the same crops prior or subsequent to that time—in November and December, and in August and September. The quantity used in these months, although not great, would, if taken into calculation, increase these averages somewhat.

Irrigation duty from Kings River.

The gross duty of the water diverted by all the canals derived from Kings River during the year ending October 31st, 1879, was 66.3 acres, and the net duty about 90.3 acres per second-foot. The major portion of this irrigation was accomplished in the period from February to July inclusive (the canals being comparatively little used the remainder of the year), as we find that in that time 85 per cent. of all the water diverted during the year was taken from the river. The gross duty in that period was reduced to 38.7 acres, and the net duty to 58 acres per second-foot.

The crops produced were largely alfalfa and cereals, and the soil a sandy alluvion, generally admitting of seepage in a high degree.

Irrigation duty from San Joaquin River.

Under the San Joaquin and Kings River Canal, the gross duty performed by the water diverted, from November, 1878, to July, 1879, inclusive, was 80 acres per second-foot. Special observations showed that with cereals the net duty on heavy adobe soil often reached 150 acres per second-foot. The crops produced are chiefly cereals and alfalfa.

Irrigation duty in Los Angeles and San Bernardino.

As far as the observations of this Department justify a conclusion, the net duty attained by water in Los Angeles and San Bernardino counties often reaches 300 acres per second-foot on the argillaceous loamy soils of the mesa lands, in the irrigation of vineyards and orchards, while in exceptional cases, where scarcity of water compels the utmost economy in its use and its distribution by means of pipes or tight conduits, the duty attains a higher figure, in one instance exceeding 1,500 acres per second-foot.

Indeed, the high duty which water is made to accomplish in all parts of these southern counties, even where it is most abundant, has no parallel in the northern portion of the State, so far as the observations of this Department extend.

It has been thought that the greater humidity of the air, where moisture-laden fogs from the ocean are of frequent occurrence, suffi-

ciently accounted for this difference, but the argument would not apply to San Bernardino County, where the ocean fogs seldom or never penetrate, and where water apparently accomplishes as high duty, under similar conditions, as in Los Angeles County, bordering the sea coast. Nor is the soil of these counties so much more favorable for irrigation than that of the irrigated zones of the San Joaquin Valley, that a higher duty could be expected of water there. The same character of soil can be found in both localities.

The explanation undoubtedly lies in the greater experience acquired in the irrigating communities of Los Angeles and San Bernardino Counties, where the art has been practiced longer than in other parts of the State, resulting in the acquirement of more skill in the use of water; in the measures which nature has compelled the irrigators to take for the conservation and economical distribution of water, and to some extent in the character of crops produced, it being an undisputed fact that vines and orchards, which form so large a proportion of the irrigated products of that section, require less water, all other conditions being equal, than the ordinary and less valuable field crops. And last, though by no means least, we find in Los Angeles and San Bernardino Counties better irrigation organizations than in the San Joaquin Valley, which tends to harmonize interests and prevent waste. Taking all things into consideration, we cannot but look upon irrigation as in a higher state of development in the extreme southern counties under consideration, than in any other portion of California.

Duty of Water—California and other Countries.

When we compare California irrigation with that of older countries whose climate and soils are similar to ours, we see that, as a general thing, we have still much to gain before we reach the high standard that is attained in water duty, as well as in methods of distribution and management elsewhere observed.

With Algeria and India.

For instance, where in California can there be found a place where the net duty of water in the irrigation of cereals is so great as that reported from Algeria—420 acres per second-foot; or where is 140 acres of corn, or any other summer field crop, irrigated with one cubic foot per second of continuous flow through the irrigation season? Certainly in no locality examined by this Department. We cannot approach even the average duty attained in the northwest provinces of India, where rice and sugar-cane—crops which require a great volume of water—form a large proportion of the area irrigated.

With Italy, France, and Germany.

It is not proper to make a comparison with the water duty of Piedmont and Lombardy, where cereals require no irrigation, and where rice and *marcite* meadows consume so great a proportion of the water used. Indeed, the character of the cultivation now prevalent in California justifies the expectation that with the more systematic, economical, and skillful systems practiced elsewhere, the duty of water should here be of the highest type. We do not cultivate rice, nor sugar cane, nor marcite meadows, to consume extravagant amounts. It is never necessary here as in North Germany, and in parts of France,

to cover our meadows in winter with a blanket of water, flowing in continuous sheets, whose aggregate depth through the season is equivalent to the enormous sum of 300 to 1,400 feet, as reported by reliable authorities.

The practices compared.

The contrast between the depth of water applied in ordinary irrigations in France, Spain, Algeria, and India, and the usual waterings common to California, is interesting. The California irrigator would consider it impossible to accomplish an irrigation with less than one to two feet, while in the sandy soils of Kern Valley and the Mussel Slough district four feet or more is not an uncommon amount to be supplied at one time. Wherever irrigation is practiced it is considered essential to have the surface moisture, artificially applied, join the natural sub-surface moisture, that there be no dry stratum between, but it is questionable if, even in the most porous of our irrigated soils, the great quantity applied does not more than effect this object, and drain away in large part below the reach of the plant-roots. More frequent applications of less amounts would doubtless ensure the same result with greater economy of water. In France, Spain, India, and elsewhere, the average depth of waterings do not exceed two to four inches. The French plan is to vary not the quantity applied, but the intervals between waterings to suit the varying requirements of soil or crop. In those countries the labor required in irrigation is less considered than the question of producing the greatest yield, and often, too, of economizing the water. In California, however, where land is cheaper and labor more dear, it is but natural to find the farmer irrigating his fields less frequently but far more copiously than is the rule in other countries, while he compensates for any dimunition of yield which his system brings about, by cultivating a wider area.

Water Supply for Irrigation.

The study of the flow of streams.

The study of a water supply is a work of time. The indications of any one season may lead to erroneous conclusions. Local traditions are often deceiving; not that those who impart information intentionally misrepresent, but being unused to special observation —not trained to exact interpretation of physical phenomena, such as the flow of streams presents—people frequently deceive themselves; so that evidence collected from casual accounts of the water quantity in the rivers is unreliable in the extreme.

The work of the department.

It has been a principal object in the conduct of this work to learn something definite of the supply of water available for irrigation. Where it has been possible to conduct observations, good results for the season of 1878–79 are at hand; and with these as a basis, fair approximations have been made to the truth for similar data of adjacent sources of supply. Although the information thus far obtained is wholly inadequate to a final consideration of the subject of water supply and distribution of waters for irrigation, we yet may make some preliminary deductions which are interesting, and in a degree instructive.

LOS ANGELES AND SAN BERNARDINO.

The data at hand.

The systematic and sustained observations on the flow of streams, for purposes of studying the water supply, were all made in the San Joaquin Valley, but some data were collected concerning this subject in San Bernardino and Los Angeles Counties. On page 19, of Appendix A, will be found an exhibit, in tabular form, of the water quantity due to the three principal rivers of this region, under certain conditions assumed as reasonable and in every way probable of occurrence. Knowing the watershed areas of these streams, the average rainfall over their mountain basins, and the proportion of water received upon them which should be drained off in the channels, we could, of course, estimate upon their discharge. The table referred to is given as an approximation to the truth, arrived at from data of this kind, and may be taken as at least affording a clue to the situation.

Estimated water supply from rainfall.

From this data we may assume that the aggregate supply of water from the Santa Ana, San Gabriel, and Los Angeles Rivers, and their tributaries from the Sierra Madre, for the four irrigation periods, should be, under ordinary circumstances, as to loss, about as follows:

1st Period—November, December, and January	3,000 cubic feet per second.
2d Period—February, March, and April	1,500 cubic feet per second.
3d Period—May, June, and July	600 cubic feet per second.
4th Period—August, September, and October	350 cubic feet per second.

Actual water supply in the streams.

According to information and some observations made more particularly during the second period of 1879, the actual supply presented at the cañons is, in the aggregate, about as follows:

1st Period—November, December, and January	2,000 cubic feet per second.
2d Period—February, March, and April	800 cubic feet per second.
3d Period—May, June, and July	400 cubic feet per second.
4th Period—August, September, and October	250 cubic feet per second.

Apparently there is an extraordinary loss from the mountain catchment basins of these streams, and the theory advanced, to the effect that this accounts for the artesian supply of water which is found under the plains below, and which comes to the surface often in natural fountains or *cienegas*, thus has a fair foundation.

To extend irrigation in San Bernardino and Los Angeles Counties.

There are three lines of action to increase the irrigated area of this region:

First—To make the water at hand do a greater duty by conducting it through conduits from which there will be less loss, and by economizing the supply in the processes of irrigation.

Second—To develop the supply which finds its way through subterranean channels, by opening the natural springs, boring more artesian wells, and constructing deep dams across the streams, to raise to the surface the waters which escape through the sands and gravel of their beds.

Third—To store surplus waters of winter for the purpose of increasing the flow through the summer months, when the demand is the

greatest. Thus greatly increasing the supply for the third period, and, perhaps, the area irrigated might, in this way, be doubled at once, without increasing the duty of the unit of measure.

Present duty of water.

The duty for this region is very variable—ranging from about 50 acres to 1,000 acres per cubic foot per second of flow for the three months of the third period, according to the character of the cultivation, the soil, and the means for conducting and distributing the supply in each instance.

There are about 57,850 acres of land irrigated from the three streams mentioned, with their tributaries. Allowing 400 cubic feet per second as their average flow through the period of greatest demand (which is about right for the season of 1879), the duty would be somewhat less than 150 acres per second-foot for the season.

The future duty of water.

From observations of some results obtained, the inference is fair that, were the population at hand to use the water, and thus the demand for irrigable lands at current prices increased, it would pay to incur expense in works necessary for the economical distribution and use of this quantity to an amount which would raise its duty up to an average of at least 300 acres per cubic foot per second, thus doubling the area now under cultivation. This result is no doubt gradually working out with the development of the country. Its realization, of course, hinges largely upon the enterprise of those who now control the water privileges, and will be affected greatly by the action which the State may take in contributing towards exact knowledge of irrigation methods and results, and establishing regulations which will look to the proper maintenance of irrigation works and prevention of waste of the water.

Development and conservation of the waters.

Aside from the outlook thus presented, it is apparent that the future prosperity of this section of the State depends largely upon the storage of water for irrigation, and the development of the underground supply in the streams. There is no section where so much good can be accomplished by storage works as in the regions now under consideration. A large surplus of water in the streams during the winter months is lost into the sea; but the character of the cultivation demands a maximum quantity during the summer time, almost when the supply is least. The opportunities for storage are many, and such enterprise, together with that of developing the supply of water now continuously flowing in the deep sands and gravels of the river beds, is worthy of fostering care and substantial encouragement on the part of the State. At least, it should be thoroughly investigated, and the true facts made of record and formulated for the use of those who may desire to invest their capital in the works necessary.

WATER SUPPLY—SAN JOAQUIN VALLEY.

Gaugings of the streams.

For the purpose of ascertaining the water quantity available for irrigation, the principal streams in the San Joaquin Valley were gauged with considerable care at different times during the year end-

ing with October, 1879, and a continuous record was kept of the rise and fall of their waters. In some cases these gaugings were made at two and even three locations on the same stream, as checks on the accuracy of each individual set of gaugings, and also, in some instances, to find the extent of loss from the channel, if any, between points. The nature of these gauging surveys and observations is referred to in Part One of this report in a general way, but it has been thought inadvisable to encumber a report intended for practical application to State questions, with details of a purely scientific or professional nature, hence nothing further is said of methods of observation, or reduction.

Preparation of the tables.

The results of this work have been reduced to tabular form, and are now to be presented.

From occasional observations of velocity, and consequent discharge, with continuous records of the fluctuations of the water's surface, tables of discharge were made for the Kern, King's, San Joaquin, and Merced Rivers; and from a record of the fluctuations of the Tuolumne at the point where it approaches the dam above La Grange, elsewhere spoken of, a similar table of discharge was calculated for this stream, by the formula applicable under such circumstances. These tables represented the average water quantity per day flowing in each of the streams mentioned, throughout the year. From less extended and complete data, similar statistics were obtained for the Stanislaus River, and for the less important streams—the Chowchilla, Fresno, Kaweah, and Tule Rivers.

Explanation of the Tables which follow.

These data furnished the basis for the following tables, which thus represent the general results of a large mass of detailed information.

The first set of tables.

Tables Nos. 1, 2, 3, 4, and 5, may be regarded as a set.

As elsewhere explained in this report (see Appendices B and C), the year has been divided into four irrigating periods of three months each, commencing with November. Thus, November, December, and January are designated the first period, and the succeeding three months the second period, and so on to the fourth.

The first four tables relate each to one of these periods, and the fifth table to the year taken as a whole. The greatest, least, and mean discharge is given for each stream, for each period, and for the year; also, the total water quantity passed in cubic feet, in each instance. The discharges are expressed in cubic feet of flow per second of time, both as to maxima, minima, and mean results, and, knowing from the topographical maps in existence, approximately the areas of the mountain basins of these streams, their quantities of discharge for each square mile of catchment have been calculated and embodied in the table, as well as the depth of water in feet drained off of each watershed, during each period, and in the year.

The second set of tables.

Tables Nos. 6 and 7 may be taken as the next set. They are based

upon the results as to the discharge of the streams, shown in the first four tables.

With the figures representing the mean discharge of each stream expressed in cubic feet of flow per second, for each period of three months as a basis, Tables Nos. 6 and 7 show the number of acres which could be irrigated by the total water quantity presented by the streams during each such period, upon the alternative suppositions that each foot of flow for the period would irrigate 50, 100, or 150 acres. The Table No. 6 gives these estimates for the first and second periods, and the Table No. 7 for the third and fourth periods.

Thus, during the first period, Kern River had an average flow of 408 cubic feet per second, and assigning the duties of 50, 100, and 150 acres to each cubic foot, it would have irrigated 20,400, 40,800, or 61,200 respectively. In like manner, during the third period, its mean rate of flow was 809 cubic feet per second, and assigning the same alternative duties its waters would have irrigated 40,450, 80,900, or 121,350 acres, as the case might be. Evidently this was a very bad season for Kern River, for several other rivers of much smaller drainage area far surpass it. Thus, the Tuolumne River during the third period had a mean discharge of 7,622 cubic feet per second, and with the duties heretofore spoken of, the total area which could have been irrigated by its flow may be taken at 381,100, 762,200, and 1,143,300 acres, as the case might be. But of course not all of these waters are available, for the interests of navigation must be looked to. Hence, the next table.

The third set of tables.

Table No. 8 is based on the one preceding it, and upon the acreage of lands in the different divisions of the valley, as heretofore given in chapter one of this Part.

The first column in this table gives the acreage of dry lands situated in each of the great natural divisions of the plains east of the swamps in the bottom of the valley and west of the rough rolling lands adjacent to the foothills.

The second column shows the acreage, in each such division, probably well suited to cultivation, as determined by partial reconnoissances made under my direction.

The figures in the third column, headed "Amount of land to be irrigated by each river," have been arrived at in the following manner:

Lands dependent upon Kern River.

Kern River is remotely situated from the other large streams of the valley. There is a vast area of land awaiting the application of its waters, a greater area than it can supply in years of ordinary flow, no doubt. In the allotment of its waters other streams need not be taken into account at all, the question being simply how much of the land it commands suitable to irrigation it can be made to cover.

Lands dependent upon Kaweah and Kings Rivers.

The Kaweah, Tule, and White River, and other small streams between Kern and Kings River, are to be regarded in the same manner. Kings River, on the contrary, must send a part of its waters to the south, where they will meet those of the Kaweah, and part to the north, where they will meet those of the San Joaquin. And in the same manner the San Joaquin will probably distribute

north as well as south on the east plain, and is already taxed for irrigation on the west side of the valley.

Lands dependent upon the Tuolumne River.

Proceeding northward, it is found that the Tuolumne, the largest of the group, has a comparatively narrow district of land adjacent to it on each side between it and the Stanislaus on the north, and the Merced on the south, so that the lands which can be watered by it on both sides, are no more than its share; thus the Stanislaus waters should all go out northward, and the Merced waters all go out to the south, leaving the districts between, to the Tuolumne to be taken out on both sides.

Lands from Kings to Merced Rivers.

We would then have the waters of the Merced, Bear, Mariposa, Chowchilla, Fresno, San Joaquin, and half of those of the Kings River (supposing this latter stream to be apportioned out evenly to the north and south), to irrigate all the land south of the Merced and north of Kings River on the east side of the valley, and all commanded by the San Joaquin, and demanding irrigation from it on the west side.

Supposing the lands on the west side to have an equal claim for water with those on the east, and the San Joaquin being the only one of the rivers from which they can draw their supply direct, then if these lands between the limits indicated were to be pooled, and the waters pooled also, the Merced and the Kings would have to share with the San Joaquin the burden of irrigating the west side district; or, in other words, as there would be a drain upon the San Joaquin to supply the demand on the west side, its duty should be lessened on the east side, and that of the other two streams each increased in proportion to their available volumes for irrigation.

Lands dependent upon Fresno and other rivers.

By an arbitrary ruling based upon the water quantities probably to be depended upon in the Fresno, Chowchilla, Mariposa, and Bear Creeks (the last two being combined under the heading of the latter one), an acreage which it is presumed they will furnish water for, if it is properly distributed, without resorting to storage works, is set down to them to be irrigated, viz.: For the Fresno River, 15,000 acres; the Chowchilla, 20,000 acres; and the Bear (and Mariposa), 10,000 acres. All other lands lying in the district through which these creeks flow, it is assumed, must depend upon the Merced River on the north, and the San Joaquin River on the south, for water, if they are ever to be irrigated.

After this arrangement for the smaller streams between Merced and San Joaquin Rivers, the apportionment of the remaining lands dependent on the main rivers was made as implied, and the figures in the third column are the partial results. Thus, by this preliminary allotment, the number set in this third column opposite the name of each stream, indicates the area in acres of the dry plain land, suitable to irrigation, and dependent upon it—the stream—for water.

This is merely a preliminary study; the water quantities are not yet known except by one season's observations; the amounts which it will be necessary to leave in the San Joaquin and its tributaries for purposes of navigation under certain circumstances is not yet

known, so the estimate has not been carried further than this first stage. The remaining columns of figures with their headings in this table explain themselves—they simply indicate in each instance the number of cubic feet per second of water which would be required from each stream to effect the irrigations expected of it under the various suppositions indicated in the headings, as to proportion of lands actually irrigated and duty performed by the water.

Table No. 9—This table shows the mean monthly discharge in cubic feet per second of the San Joaquin River, and the streams which are directly tributary to it in its upper course, for each month of the year ending with October, 1879. And these figures are so arranged as to exhibit the aggregate mean quantity per second which should have been flowing in the main stream below each of its tributaries. Thus, in November, of 1878, the San Joaquin River was carrying out from the foothills 275 cubic feet per second; below the mouth of the Merced it should have had 524 feet; below the Tuolumne 604 feet; and below the Stanislaus 662 cubic feet per second.

Also, during the month of June there should have been in the San Joaquin, at the points above mentioned, 5,753, 10,868, 19,578, and 23,514 cubic feet per second, respectively.

Table No. 10—This is a comparison of the results obtained in the matter of probable demand for water from the San Joaquin and its tributaries, as shown by the last table, with the actual flow of those streams as indicated by the gaugings made during the past season.

The object is to show (under the various suppositions as to duty of water and amount of land to be irrigated during the four periods, of three months each, of the year), how much water would be left in the San Joaquin River above and below each of its tributaries, supposing none to be lost or gained by it or them, en route.

This table is prepared with a view of forming some idea of the effect of irrigation upon the navigable depth of the main river in its different divisions.

TABLE No. 1.

Discharge of the Rivers of San Joaquin Valley.

First Period—November, December, and January—Season, 1878–1879.

Name of River.	Drainage area in square miles	Number of days of flood	Maximum rate of discharge. Time in days	Maximum rate of discharge. Amount in cu. ft. per second	Maximum rate of discharge. Amount in cu. ft. per sec. per square mile	Minimum rate of discharge. Time in days	Minimum rate of discharge. Amount in cu. ft. per second	Minimum rate of discharge. Amount in cu. ft. per sec. per square mile	Mean rate of discharge. Cubic feet per second	Mean rate of discharge. Cubic feet per sec. per square mile	Total discharge in cubic feet	Equivalent in depth and area. Depth of water drained off, in feet	Equivalent in depth and area. Area of equivalent one foot deep, acres	Remarks.
Kern River	2,382	92	1	686	0.29	1	389	0.16	408	0.17	3,246,351,000	0.048	74,530	Nov., Dec., and part of January, estimated.
Tule River	446	92	----	334	0.75	----	67	0.15	27	0.06	214,623,000	0.017	4,830	Estimated.
Kaweah River	608	92	----	760	1.25	----	109	0.18	67	0.11	532,583,000	0.031	12,230	Partly estimated.
Kings River	1,855	92	1	3,425	1.85	23	210	0.11	321	0.17	2,549,307,200	0.049	58,520	Observed.
San Joaquin River	1,630	92	31	2,758	1.69	23	272	0.17	364	0.22	2,894,918,400	0.064	66,460	Observed.
Fresno River	260	14	3	80	0.31	3	32	0.22	9	0.04	73,094,400	0.011	1,680	Estimated.
Chowchilla River	303	15	----	106	0.35	----	45	0.21	10	0.03	82,944,000	0.010	1,900	Estimated.
Merced River	1,075	92	31	2,687	2.50	23	101	0.09	245	0.23	1,947,993,200	0.065	44,720	Observed.
Tuolumne River	1,513	92	----	7,907	5.23	----	80	0.05	403	0.27	3,202,174,080	0.076	73,510	Observed.
Stanislaus River	971	92	----	5,340	5.50	----	77	0.08	290	0.30	2,305,152,000	0.085	52,920	Partly estimated.
Totals and av'ges	11,043	----	----	--------	--------	----	------	--------	2,145	0.194	17,049,140,280	0.055	391,390	

TABLE No. 2.

Discharge of the rivers of San Joaquin Valley.

Second Period—February, March, and April—Season, 1878-1879.

Name of River.	Drainage area in square miles	Number of days of flow	Maximum rate of discharge.			Minimum rate of discharge.			Mean rate of discharge.		Total discharge, in cubic feet.	Equivalent in depth and area.		Remarks.
			Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Cubic feet per second	Cu. ft. per sec. per sq. mile		Depth of water drained off, in feet	Area of equivalent one foot deep, acres	
Kern River	2,382	89	1	1,054	0.44	1	466	0.20	636	0.27	4,886,784,000	0.073	112,190	Observed.
Tule River	446	89	----	1,115	2.50	----	112	0.25	248	0.56	1,907,020,000	0.153	43,780	Estimated.
Kaweah River	608	89	----	2,280	3.75	----	152	0.25	400	0.66	3,075,840,000	0.181	70,610	Partly estimated.
Kings River	1,855	89	1	8,400	4.53	1	295	0.16	2,694	1.45	20,714,832,000	0.401	475,550	Observed.
San Joaquin River	1,630	89	1	7,978	4.89	1	272	0.17	2,671	1.64	20,541,681,600	0.452	471,570	Observed.
Fresno River	260	89	2	202	0.78	1	60	0.23	105	0.40	805,507,200	0.111	18,490	Partly estimated.
Chowchilla River	303	89	----	1,162	3.83	----	78	0.26	136	0.44	1,045,785,600	0.124	24,010	Partly estimated.
Merced River	1,075	89	31	10,750	10.00	1	254	0.24	3,313	3.08	25,473,888,000	0.850	584,800	Observed.
Tuolumne River	1,513	89	----	27,940	18.47	----	843	0.56	5,611	3.71	43,147,555,200	1.023	990,540	Observed.
Stanislaus River	971	89	----	17,963	18.50	----	582	0.60	3,884	4.00	29,866,406,400	1.103	685,640	Partly estimated.
Totals and av'ges	11,043	----	----	----	----	----	----	----	19,696	1.783	151,465,300,000	0.492	3,477,160	

TABLE No. 3.

Discharge of the rivers of San Joaquin Valley.

Third Period—March, June, and July—Season of 1878–1879.

Name of River.	Drainage area in square miles	Number of days of flow	Maximum rate of discharge.			Minimum rate of discharge.			Mean rate of discharge.		Total discharge in cubic feet	Equivalent in depth and area.		Remarks.
			Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Cubic feet per second	Cubic feet per sec. per square mile		Depth of water drained off, in feet	Area of equivalent one foot deep, acres	
Kern River	2,382	92	1	1,231	0.52	1	386	0.16	809	0.34	6,433,344,000	0.097	147,700	Observed.
Tule River	446	92	----	780	1.75	----	89	0.20	178	0.40	1,414,922,000	0.113	32,480	Estimated.
Kaweah River	608	92	----	1,368	2.25	----	122	0.20	306	0.50	2,435,574,000	0.144	55,890	Partly estimated.
Kings River	1,855	92	1	9,030	4.87	1	635	0.34	3,557	1.92	28,275,134,400	0.547	649,110	Observed.
San Joaquin River	1,630	92	1	13,016	7.99	1	735	0.45	4,220	2.59	33,541,430,400	0.738	770,000	Observed.
Fresno River	260	42	6	102	0.39	----	------	------	31	0.12	246,832,000	0.034	5,670	Partly estimated.
Chowchilla River	303	42	----	121	0.40	----	------	------	34	0.11	270,160,000	0.032	6,200	Partly estimated.
Merced River	1,075	92	2	8,600	8.00	1	357	0.33	3,770	0.35	29,969,280,000	1.000	688,000	Observed.
Tuolumne River	1,513	92	----	17,405	11.50	----	1,175	0.78	7,622	5.04	60,586,790,400	1.436	1,390,880	Observed.
Stanislaus River	971	92	----	11,166	11.50	----	757	0.78	3,398	3.50	27,010,022,400	0.998	620,060	Partly estimated.
Totals and av'ges	11,043	----	----	-------	------	----	------	------	23,925	2.166	190,183,489,600	0.617	4,366,010	

TABLE No. 4.

Discharge of the Rivers of San Joaquin Valley.

Fourth Period—August, September, and October—Season of 1878-1879.

Name of River.	Drainage area in square miles	Number of days of flow	Maximum rate of discharge.			Minimum rate of discharge.			Mean rate of discharge.		Total discharge in cubic feet	Equivalent in depth and area.		Remarks.
			Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Cubic feet per second	Cubic feet per sec. per square mile		Depth of water drained off, in feet	Area of equivalent one foot deep, acres	
Kern River	2,382	92	1	387	0.16	1	140	0.06	200	0.08	1,592,179,200	0.024	36,550	Observed.
Tule River	446	92	----	89	0.20	----	45	0.10	36	0.08	283,779,000	0.023	6,510	Estimated.
Kaweah River	608	92	----	152	0.25	----	80	0.13	61	0.10	483,299,200	0.029	11,090	Observed.
Kings River	1,855	92	31	5,600	3.02	31	240	0.13	384	0.21	3,049,920,000	0.059	70,020	Observed.
San Joaquin River	1,630	92	3	735	0.45	31	295	0.18	404	0.25	3,213,129,600	0.071	73,763	Observed.
Fresno River	260	----	----	----	----	----	----	----	----	----	----	----	----	No water.
Chowchilla River	303	----	----	----	----	----	----	----	----	----	----	----	----	No water.
Merced River	1,075	92	31	450	0.42	30	150	0.14	288	0.27	2,290,240,000	0.076	52,580	Observed.
Tuolumne River	1,513	92	----	1,030	0.68	----	54	0.04	383	0.25	3,047,587,200	0.072	69,960	Observed.
Stanislaus River	971	92	----	680	0.70	----	39	0.04	194	0.20	1,542,067,200	0.057	35,400	Partly estimated.
Totals and av'gs.	11,043	----	----	----	----	----	----	----	1,950	0.18	15,502,201,400	0.054	355,880	

TABLE NO. 5.

Discharge of the rivers of San Joaquin Valley.

From November, 1878, to October, 1879, inclusive—Season of 1878-1879.

NAME OF RIVER.	Drainage area in square miles	Time of flow in days	Maximum rate of discharge.			Minimum rate of discharge.			Mean rate of discharge.		Total discharge in cubic feet	Equivalent in depth and area.		Remarks.
			Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Time in days	Amount in cu. ft. per second	Amount in cu. ft. per second per sq. mile	Cubic feet per second	Cubic feet per sec. per square mile		Depth of water drained off, in feet	Area of equivalent one foot deep, acres	
Kern River	2,382		1	1,231	0.52	1	1.40	0.06	512	0.215	16,158,658,200	0.243	370,950	Observed.
Tule River	446			1,115	2.50		.45	0.10	121	0.271	3,820,344,000	0.307	87,700	Estimated.
Kaweah River	608			2,280	3.75		.80	0.13	207	0.340	6,527,296,200	0.385	149,850	Partly estimated.
Kings River	1,855		2	9,030	4.87	23	2.10	0.11	1,731	0.933	54,589,193,600	1.056	1,253,200	Observed.
San Joaquin River	1,630		1	13,016	7.99	57	2.72	0.17	1,909	1.107	60,191,160,000	1,324	1,381,800	Observed.
Fresno River	260		3	202	0.78				36	0.137	1,125,433,600	0.155	25,830	Partly estimated.
Chowchilla River	303		1	1,162	3.83				44	0.146	1,398,889,600	0.166	32,110	Estimated.
Merced River	1,075		1	10,750	10.00	23	1.01	0.09	1,896	1.764	59,681,401,200	1.991	1,370,100	Observed.
Tuolumne River	1,513			27,940	18.47		.54	0.04	3,488	2.305	109,984,106,880	2.607	2,524,890	Observed.
Stanislaus River	971			17,963	18.50		.39	0.04	1,926	1,984	60,723,648,000	2,243	1,394,020	Partly estimated.
Totals and av'ges	11,043								11,870	1.075	374,200,131,280	1.215	8,590,450	

TABLE No. 6.

Showing the mean discharge of rivers, 1878–1879, and amount of land they are capable of irrigating.

Name of River.	First Period—November, December, and January, 1878–1879.				Second Period—February, March, and April, 1879.				Remarks.
	Mean discharge in cubic feet per second	Acres irrigable under a duty of 50 acres per cubic foot per second	Acres irrigable under a duty of 100 acres per cubic foot per second	Acres irrigable under a duty of 150 acres per cubic foot per second	Mean discharge in cubic feet per second	Acres irrigable under a duty of 50 acres per cubic foot per second	Acres irrigable under a duty of 100 acres per cubic foot per second	Acres irrigable under a duty of 150 acres per cubic foot per second	
Kern River	408	20,400	40,800	61,200	636	31,800	63,600	95,400	Observed.
Tule River	27	1,350	2,700	4,050	248	12,400	24,800	37,200	Partly estimated.
Kaweah River	67	3,350	6,700	10,050	400	20,000	40,000	60,000	Partly estimated.
Kings River	321	16,050	32,100	48,150	2,694	134,700	269,400	404,100	Observed.
San Joaquin River	364	18,200	36,400	54,600	2,671	133,550	267,100	400,650	Observed.
Fresno River	9	450	900	1,350	105	5,250	10,500	15,750	Partly estimated.
Chowchilla River	10	500	1,000	1,500	136	6,800	13,600	20,400	Estimated.
Merced River	245	12,250	24,500	36,750	3,313	165,650	331,300	496,950	Observed.
Tuolumne River	403	20,150	40,300	60,450	5,611	280,550	561,100	841,650	Observed.
Stanislaus River	290	14,500	29,000	43,500	3,884	194,200	388,400	582,600	Partly estimated.
Totals	2,145	107,250	214,500	321,750	19,696	984,800	1,969,600	2,954,400	

TABLE No. 7—[Continued from Table No. 6.]

Showing the mean discharge of rivers, 1878–1879, and amount of land they are capable of irrigating.

Name of River.	Third Period—May, June, and July, 1879.				Fourth Period—Aug., Sept., and Oct., 1879.				Remarks.
	Mean discharge in cubic feet per second	Acres irrigable under a duty of 50 acres per cubic foot per second	Acres irrigable under a duty of 100 acres per cubic foot per second	Acres irrigable under a duty of 150 acres per cubic foot per second	Mean discharge in cubic feet per second	Acres irrigable under a duty of 50 acres per cubic foot per second	Acres irrigable under a duty of 100 acres per cubic foot per second	Acres irrigable under a duty of 150 acres per cubic foot per second	
Kern River	809	40,450	80,900	121,350	200	10,000	20,000	30,000	Observed.
Tule River	178	8,900	17,800	26,700	36	1,800	3,600	5,400	Partly estimated.
Kaweah River	306	15,300	30,600	45,900	61	3,050	6,100	9,150	Partly estimated.
Kings River	3,557	177,850	355,700	533,550	384	19,200	38,400	57,600	Observed.
San Joaquin River	4,220	211,000	422,000	633,000	404	20,200	40,400	60,600	Observed.
Fresno River	31	1,550	3,100	4,650					Partly estimated.
Chowchilla River	34	1,700	3,400	5,100					Estimated.
Merced River	3,770	188,500	377,000	565,500	288	14,400	28,800	43,200	Observed.
Tuolumne River	7,622	381,100	762,200	1,143,300	383	19,150	38,300	57,450	Observed.
Stanislaus River	3,398	169,900	339,800	509,900	194	9,700	19,400	29,100	Partly estimated.
Totals	23,925	1,196,250	2,392,500	3,588,750	1,950	97,500	195,000	292,500	

TABLE No. 8.

Showing the probable quantity of water required from the rivers of San Joaquin Valley for irrigation purposes.

Name of River.	Dry plains between rivers, acres	Suited to irrigation, acres	Amount of land to be irrigated by each river	Amount of water required to irrigate the land capable of irrigation.				Water to be diverted if one-half of irrigable land be irrigated in any one period.			
				Duty of water, 50 acres per cubic foot per second	Duty of water, 100 acres per cubic foot per second	Duty of water, 150 acres per cubic foot per second	Duty of water, 200 acres per cubic foot per second	Duty of water, 50 acres per cubic foot per second	Duty of water, 100 acres per cubic foot per second	Duty of water, 150 acres per cubic foot per second	Duty of water, 200 acres per cubic foot per second
Kern River		475,000	475,000	9,500	4,750	3,813	2,875	4,750	2,875	2,156	1,437
To sixth standard south	270,580	155,000									
Tule River			125,000	2,500	1,250	938	625	1,250	625	469	313
	370,370	185,000									
Kaweah River			215,000	4,300	2,150	1,588	1,025	2,150	1,025	769	513
	344,610	230,000									
Kings River			434,000	8,680	4,340	3,255	2,170	4,340	2,170	1,628	1,085
	667,190	410,000									
San Joaquin River			480,000	9,600	4,800	3,600	2,400	4,800	2,400	1,800	1,200
	253,830	165,000									
Fresno River			15,000	300	150	113	75	150	75	57	38
	214,160	145,000									
Chowchilla River			20,000	400	200	150	100	200	100	75	50
	246,180	165,000									
Bear Creek			10,000	200	100	75	50	100	50	38	25
	169,560	120,000									
Merced River			476,000	9,520	4,760	3,570	2,380	4,760	2,380	1,785	1,190
	213,510	165,000									
Tuolumne River			295,000	5,900	2,950	2,213	1,475	2,950	1,475	1,107	738
	170,610	130,000									
Stanislaus River			100,000	2,000	1,000	750	500	1,000	500	375	250
		100,000									

TABLE No. 9.

Average monthly discharge of San Joaquin River and its principal tributaries—Season 1878–1879.

Month.	San Joaquin.	Merced.	San Joaquin below the Merced—Estimated.	Tuolumne.	San Joaquin below the Tuolumne—Estimated.	Stanislaus.	San Joaquin below the Stanislaus—Estimated.
November, 1878	275	249	524	80	604	58	662
December, 1878	272	240	512	80	592	58	650
January, 1879	543	245	788	1,038	1,826	747	2,573
February, 1879	1,626	604	2,230	3,866	6,096	2,992	9,088
March, 1879	2,300	2,858	5,158	4,845	10,003	3,790	13,793
April, 1879	4,031	6,252	10,283	8,032	18,315	4,800	23,115
May, 1879	5,753	5,115	10,868	8,710	19,578	3,936	23,514
June, 1879	5,729	5,082	10,811	11,171	21,982	5,010	26,992
July, 1879	1,226	1,160	2,386	3,100	5,486	1,420	6,906
August, 1879	542	450	992	660	1,652	332	1,984
September, 1879	375	225	600	58	658	35	693
October, 1879	295	150	445	422	867	210	1,077

TABLE No. 10.

Showing the possible effect of prospective irrigation upon the waters of the San Joaquin River above and below each tributary.

1878-1879.	First Period. November, December, January	Second Period. February, March, April	Third Period. May, June, July	Fourth Period. August, September, October
Above Merced River.				
Water flowing in San Joaquin River	364	2,671	4,220	404
Water which may be required for irrigation:				
If water diverted have a duty of 50 acres	4,800	4,800	4,800	1,200
If water diverted have a duty of 100 acres	2,400	2,400	2,400	600
If water diverted have a duty of 150 acres	1,800	1,800	1,800	400
If water diverted have a duty of 200 acres	1,200	1,200	1,200	300
Water remaining in the river:				
If water diverted have a duty of 50 acres	*— 4,436	— 2,129	— 580	— 796
If water diverted have a duty of 100 acres	— 2,036	271	1,820	— 196
If water diverted have a duty of 150 acres	— 1,436	871	2,420	4
If water diverted have a duty of 200 acres	— 836	1,471	3,020	104
Above Tuolumne River.				
Water flowing in San Joaquin River	609	5,984	7,990	692
Water which may be required for irrigation:				
If water diverted have a duty of 50 acres	9,560	9,560	9,560	2,140
If water diverted have a duty of 100 acres	4,780	4,780	4,780	1,195
If water diverted have a duty of 150 acres	3,555	3,555	3,555	889
If water diverted have a duty of 200 acres	2,390	2,390	2,390	598
Water remaining in the river:				
If water diverted have a duty of 50 acres	— 8,951	— 3,576	— 1,570	— 1,448
If water diverted have a duty of 100 acres	— 4,171	1,204	3,210	— 503
If water diverted have a duty of 150 acres	— 2,946	2,429	4,435	— 197
If water diverted have a duty of 200 acres	— 1,781	3,594	5,600	94

* Minus signs indicate the deficiency after the river was wholly exhausted.

TABLE No. 10—Concluded.

1878–1879.	First Period.	Second Period.	Third Period.	Fourth Period.
	November, December, January	February, March, April	May, June, July	August, September, October
ABOVE STANISLAUS RIVER.				
Water flowing in San Joaquin River	1,012	11,095	15,612	1,075
Water which may be required for irrigation:				
If water diverted have a duty of 50 acres	12,510	12,510	12,510	3,128
If water diverted have a duty of 100 acres	6,255	6,255	6,255	1,564
If water diverted have a duty of 150 acres	4,662	4,662	4,662	1,146
If water diverted have a duty of 200 acres	3,128	3,128	3,128	782
Water remaining in the river:				
If water diverted have a duty of 50 acres	*—11,498	— 1,415	3,102	— 2,053
If water diverted have a duty of 100 acres	— 5,243	4,840	9,357	— 489
If water diverted have a duty of 150 acres	— 3,650	6,433	10,950	— 171
If water diverted have a duty of 200 acres	— 2,116	7,967	12,484	293
BELOW STANISLAUS RIVER.				
Water flowing in San Joaquin River	1,302	14,979	19,010	1,269
Water which may be required for irrigation:				
If water diverted have a duty of 50 acres	13,510	13,510	13,510	3,378
If water diverted have a duty of 100 acres	6,755	6,755	6,755	1,689
If water diverted have a duty of 150 acres	5,037	5,037	5,037	1,259
If water diverted have a duty of 200 acres	3,378	3,378	3,378	845
Water remaining in the river:				
If water diverted have a duty of 50 acres	— 12,208	1,469	5,500	— 2,109
If water diverted have a duty of 100 acres	— 5,453	8,224	12,255	— 420
If water diverted have a duty of 150 acres	— 3,735	9,942	13,973	10
If water diverted have a duty of 200 acres	— 2,076	11,601	15,632	424

NOTE.—This table is made up on the supposition that only half of the areas, in each instance, set opposite the names of the rivers in Table No. 8 will be irrigated in any one period of three months; and upon the further supposition that the demand for water during the first three periods will be uniform, but in the fourth reduced to 25 per cent.

* Minus signs indicate the deficiency after the river was wholly exhausted.

DEDUCTIONS FROM THE TABLES.

Considering the fact that all of these results depend upon observations on the streams for but one season, and upon only a partial or superficial knowledge of the field to be irrigated, it would be ill-advised to base any conclusions purporting to be final upon them. We may, however, make some deductions of interest, even if not final, and, though they may not be substantiated in the future, they will still show at least how important it is that the subject receive earnest attention from the State.

Kern River water supply.

From Table No. 7—We see that the greatest average flow of Kern River was during the third period, when it discharged 809 cubic feet per second; that, at the rate it is now used, this water would only irrigate about 56,630 acres; at a duty of 100 acres per cubic foot per second it would only irrigate 80,900 acres, and at the rate of 200 acres, 161,800 acres; whereas, by Table No. 9, we see that there are 475,000 acres of dry land suited to irrigation requiring water from this river, including reclaimed swamp lands which are also dependent upon it, and require watering as much as the plain lands.

Kings River water supply.

In like manner, we see Kings River with only enough water during the second period—the time of greatest demand—to irrigate about 80,000 acres of land at the rate it is used by the canals taking water on the north bank, near Centerville, and distributing it near Fresno, whereas there are 434,000 acres of land well suited to irrigation dependent upon it.

But we also see that if this water were made to do its full duty of 200 acres per second-foot, there would have been enough during the second period, and more than enough during the third, to have irrigated the whole territory of 434,000 acres. This river makes a better showing than any other in the extreme southern portion of the valley.

San Joaquin River water supply.

Table No. 9.—Taken in connection with the results of other observations of the department, this table is instructive. It shows that during the months of April, May, and June of 1879, upwards of 23,000 cubic feet of water per second were contributed to the San Joaquin River at points above where it was observed in one channel, below the mouth of the Stanislaus River, in June.

Upon that occasion, making liberal allowance for loss out of one of the crevasses above the point of observation, not over 18,000 cubic feet per second were flowing. Now, the aggregate of the average flow of the main river and its tributaries was for that month nearly 27,000 cubic feet per second. It certainly appears that the San Joaquin River loses water in its bed instead of receiving any through its sands. And this conclusion is borne out by the results of observations on the rivers where they were gauged at several points, the lower station always showing the least flow by a considerable volume.

What then are we to expect if large volumes are taken from the San Joaquin for irrigation purposes?

Without attempting to answer that question, with the present par-

tial insight into the matter, we may examine the next table with interest.

Upper San Joaquin River.

Table No. 10.—From this table we see, if water is to do a duty in irrigation of only 50 acres, as it does generally at present, that above the mouth of the Merced, supposing the one-half of the lands dependent upon the San Joaquin, and suited to irrigation, to demand watering in the first period (November, December, and January), there was only a supply of 364 cubic feet to furnish a demand of 4,800; in the second period, a supply of 2,671 to a demand of 4,800; in the third period, a supply of 4,220 to a demand of 4,800, etc.

And under the same conditions, with a duty of 150 acres per second-foot (a duty which we should expect), the result would be a demand of 1,800 cubic feet as against a supply of 364, 2,671, and 4,220 cubic feet per second for the first, second, and third periods, respectively.

Between the Merced and Tuolumne.

Again, the result, as indicated below the Merced and above the Tuolumne, with all of the conditions first above mentioned, would be (duty 50 acres), first period, supply 609, demand 9,560; second, supply 5,984, demand 9,560; third, supply 7,990, demand 9,560; fourth, supply 692, demand 2,140.

A short supply at duty fifty.

It is plain that at this rate not nearly all of the lands of the valley can be irrigated. Glancing down the table we find that opposite the duty of 50 acres per cubic foot per second, it is not until we get below the mouth of the Tuolumne that we find a balance of water to the credit of the river, and then only in the third period, while below the mouth of the Stanislaus we find a balance during the second period of about 12½ per cent. of what ought to be there; and in the third period, in like manner, a result of about 25 per cent. present.

A better outlook with duty one hundred and fifty.

With the duty of 150 acres we find, of course, a better outcome. But still all would be taken out during the first period; of 5,984 cubic feet, only 2,429 would be left during the second period; of 7,990, only 4,435 during the third; and in the fourth there would apparently be a deficiency of 197 cubic feet per second.

What has been said here concerning these tables is more with the view of attracting attention to them than by way of a discussion of the results they show. When these observations shall have extended over a longer period it will be proper to enter upon in a thorough discussion.

CONCLUSIONS.

Irrigation water supply.

On the whole, it may be said that, as matters are going now, the water supply in the San Joaquin and Tulare Valleys appears to be short, even when we allow for but one half of the dry plains well suited to irrigation, being served during one irrigation period of three months, and do not allow anything for foothill or mountain irrigation, and for swamp land irrigation, which will come about in time.

Further than this, however, it is quite apparent that with the duty of water raised to what it should be—150 to 250 acres per second-foot—the case wears a much more cheerful aspect, except in the case of the country south of the Kaweah River, where, even though this past season has been a remarkably unfavorable one in which to observe the rivers, the indications are that a large area of land will have to go unwatered for many years to come, unless, indeed, the surplus waters of Kern River, during wet seasons, can be saved by storage.

We are now brought to the point where it is well that the practical lessons be formulated from this study; and for this purpose, I call special attention to the next chapter, where certain important facts are brought out and illustrated, and some practical deductions and recommendations made.

Irrigation and navigation.

With respect to the effect of irrigation on the navigable depth of the San Joaquin River, Table No. 10 does not afford all of the data upon which this question must be discussed, as shown in the next chapter of this report. Nevertheless, it shows that a large accession of waters must be received from the sands of the river bed and banks, to preserve a navigable depth to this river, if the plains dependent upon it are ever to be irrigated, even upon the basis of the largest duty of water to be expected; for at its best last season the stream was only navigable a short distance above the Merced, and then for only a short time.

No doubt if the whole channel were improved, a very good navigable depth could be maintained with 5,000 cubic feet of water per second, but in its present condition it will take twice that volume.

CHAPTER IV.

RESULTS OF THE INVESTIGATION.

The course of investigation followed, and the immediate objects aimed at in conducting the irrigation inquiry, have been outlined in Part One of this report, and foreshadowed in the preceding chapters of this Part.

As fruit of the work done, a vast amount of interesting and valuable information, concerning the water supply for irrigation, the lands already, and those to be, irrigated, and the use of water for irrigation, together with the results thereof, has been collected.

The more important facts of general information have been brought forward in preceding chapters, and much of this detail data, so far as it could be brought into form in the limited time available, is embodied in the special reports appended. The present paper is confined to an elucidation of the general facts and practical points brought out by the results of this work.

"THE IMPORTANT FACTS THAT HAVE BEEN ASCERTAINED."

As a very important result of the inquiry into this subject of irrigation, there stands prominently forth the complete realization of the consequence of certain facts, most of which are to be observed in part, at least, wherever artificial watering of the soil is needed and practiced throughout the State.

Commonplace points.

Not a few of these points were by some persons fully understood, and in a degree generally recognized, previous to the undertaking of this investigation. Their frequent occurrence, however, has been fully established by the inquiry made; and although commonplace in themselves, as some of them undoubtedly are, they appear as such important factors in the problems of irrigation with which the State is called upon to deal, that it is sought to emphasize their mention here. The ultimate bearing of these facts—their influence in the general problems spoken of—will be considered subsequent to their review. Their immediate importance is made apparent when it is remembered that the State Engineer has been directed to designate the boundaries for irrigation districts, and to make studies of works for the irrigation thereof, for under the circumstances which have been developed as explained it is impossible, immediately, to comply with this instruction to any good purpose.

The irrigation questions.

The leading questions for solution, in the engineering problems of irrigation, are three in number, as follows: (1.) What are to be regarded as irrigable lands? (2.) What is the available water supply for irrigation? (3.) What extent of land may a given quantity of water be made to irrigate?

The important points to which it is desired to call special attention, are grouped as relating: To the lands to be irrigated; the water supply; the appropriation and use of water in California.

Important Facts—Class I.

THE LANDS TO BE IRRIGATED.

(*A*)—*Farming by irrigation will not be practiced in the State at all favorable localities where it is necessary.*

Certain classes or kinds of land which are looked upon as desirable for cultivation by irrigation in some portions of the State, are not now, and may never be so regarded in other quarters, although the climate under which they are there placed is equally dry, and irrigation quite as much a necessity as in those localities where they are or will be irrigated.

This is a fact having a bearing in the matter of determining what are to be considered as irrigable lands.

First illustration.

North of Fresno County irrigation is practiced upon lands well up in the foothills or mountains, and it is probable that this irrigation will greatly increase in extent with the lapse of time, in the regions where the climate is favorable for summer residence, and where a market can conveniently be had for fruits and such other produce as can be raised to advantage on hill lands. But it is not at all probable that the same class of lands, where these advantages are not had—as for instance, south of Tuolumme County, and bordering the great valley—will ever be brought under irrigation, except in isolated cases, and to a limited extent.

Second illustration.

The irrigation of summer crops is just as necessary upon the dry plains of the Sacramento Valley and upon the east side of the northern portion of the San Joaquin Valley, as in the hotter regions further south and on the west side; yet it is probable that heavy adobe lands, such as have to be irrigated on the west side of the San Joaquin Valley, will never be brought under irrigation to any great extent in the localities first named, because, seeing that in San Joaquin County and further north irrigation to any great extent is not an absolute necessity, only those soils will there be watered which are especially adapted to wet farming, and the heavy adobes are not.

Third illustration.

In the Counties of Los Angeles and San Bernardino there are broad areas of valley lands covering thousands of acres, upon which irrigation is not considered desirable, for the reason that they receive moisture by percolation from some underground sources, and do not require, at present at least, to be artificially watered, although the climate is just as dry with them as where irrigation is necessary, and although lands of the same soil, composition, and topographical con-

figuration which have not the subsoil moisture, do require it in the same neighborhood.

Fourth illustration.

Rolling lands or mesa lands, irrigated where the climate is particularly adapted to the cultivation of tropical fruits and the vine, as for instance in Los Angeles and San Bernardino Counties, will probably never call for any considerable recognition as irrigable lands, when from climatic or other causes a like class of cultivation is not desirable.

(*B*)—*Mountain lands require and demand irrigation as well as the great dry plains of the valleys.*

Irrigation is generally looked upon as desired only on the dry plains of the great valleys of the State. The law under which the State Engineer is called upon to act contemplates only a study of "the problems of irrigation of the plains;" whereas, irrigation, under some circumstances, is equally necessary, and extensively practiced even, not only upon the foothills, but upon mountain lands as well as in the great-plain valleys.

This is a fact, also, having a bearing in the matter of determining what are to be considered as irrigable lands.

First illustration.

The cultivation of foothill and mountain lands by irrigation was begun with water taken from ditches which were constructed for mining purposes, and it has developed as the demand for water for mining has decreased. Gradually but surely it is coming to pass that nearly all of the waters carried by these ditches will be used for irrigation, and then there will be, doubtless, regions of large area, in the foothills and mountains east of the Sacramento Valley, more thoroughly irrigated than the plains of the valley itself will be, or than similar plains in the northern part of the San Joaquin Valley.

Second illustration.

In Shasta and Plumas, as well as in other counties, there are ditches constructed in hilly or mountainous country, expressly for irrigation purposes, and the probabilities are that others will be built out from the large streams for a like purpose; but the greater probability is that water for irrigation will be stored in the valleys and cañons of the small streams, in reservoirs—somewhat after the tank system of India and Ceylon—and that thus large areas of the foothills will be brought under irrigation for the cultivation of clover, fruits, and the vine.

(*C*)—*Dry lands vary greatly in quality of soil and subsoils.*

Lands for whose successful cultivation artificial watering is necessary, are very variable, not only in topographical configuration, but also in quality of soil and subsoil, and consequent adaptability to use in wet farming.

This is a fact having not only a direct bearing in the matter of determining the extent of land which can be irrigated with the

water supply available from any one of the several sources, but also upon the question as to what proportion of any body of irrigable land will probably be irrigated.

First illustration.

In Merced County, on the east side of the valley, there are lands with heavy adobe soils, and others with sandy soils, which will probably be commanded for irrigation by the same canals. The sandy soils are well adapted to irrigation and the adobes are not. The proportion in which these soils are to be found in the district will to a considerable extent govern the quantity of land brought under irrigation, and the frequency with which it must be irrigated.

Second illustration.

On the west side of the San Joaquin River we find lands whose slope and surface present the most perfect condition for easy application of water by irrigation, but whose soil is a stiff alkaline adobe, underlaid a foot or two beneath the surface with impervious hard-pan. Adjoining this belt of country in the north, there are soils nearly as perfect in conformation, but of a totally different nature, consisting of an argillaceous loam of great depth, underlaid with gravel, presenting extreme contrast to the adobe soils in their adaptability to cultivation by irrigation. The alkaline adobes will not soak up the waters after the lands have been under irrigation some time, and they dry out quickly, so that four to eight irrigations are required to raise a crop. The loamy soils receive the waters freely and hold them, so that one or two irrigations per crop may suffice.

Third illustration.

On the east side of the San Joaquin, as far northward as the Stanislaus River, the soils are generally sandy, although large bodies of adobe are found near Merced. The sandy land has an underlying stratum of hard-pan, resembling a soft sandstone, which, over large areas is quite near the surface and occasionally crops out, while throughout a larger portion of the country the top soil is comparatively deep. Much of this land must remain in a great measure barren, on account of the hard-pan cropping out or being near the surface, while where there is deep sandy soil, irrigation will be extensively practiced; and where there is a fair depth of soil, less water will be required to accomplish the irrigation than where it is very deep; but where the soil is comparatively shallow, a greater number of irrigations per year or crop will be necessary to prevent drying out.

(*D*)—*The water supply may be short where there is most land to irrigate.*

The greatest extent of land requiring irrigation is to be found in the portions of the State where the water supply is least in amount.

This fact, of course, has a direct bearing upon the matter as to what classes of lands are to be considered irrigable in the several sections of the State.

First illustration.

There are in San Bernadino and Los Angeles Counties about 1,400 square miles of cultivable land ordinarily too dry for farming without irrigation. Yet the water supply this last year was barely suffi-

cient for the irrigation of 128 square miles, and in order to remedy this defect, a comprehensive system for storing water must be resorted to; though the supply can be made to accomplish more than it does at present, by a better class of distributing works.

Second illustration.

In Kern County there are 2,076 square miles of dry valley land, and 247 square miles of swamp land, wholly or partially reclaimed and requiring irrigation, which depend almost wholly upon Kern River for their water supply. The small mountain brooks, of which the San Emidio, Plato, Canada de las Uvas, Tecuza, Tejon, Caliente, and Posa, are the most important, may be made to irrigate a very small part of these lands along the rim of the valley, but the great body of them must be irrigated, if at all, from Kern River, which discharged during the first seven months of the past year barely sufficient water to have covered 450 square miles to a depth of one foot, allowing nothing for loss. True, the season was a remarkably dry one, and the flow of the river was considerably less than ordinary, but as compared with the streams further north, and the area of land dependent upon them for future irrigation, the supply is exceedingly small.

(*E*)—*Variations in soils and subsoils affect the quantity of water required to effect the irrigations.*

Natural variations in the character of soil, and more particularly in the character of subsoils, as well as in other characteristics of lands, may and generally do bring with them great variations in the area of land which can be irrigated with or by a given quantity of water.

This fact of course has a direct bearing upon the whole subject of apportionment of waters to the lands, and consequently upon the question as to what we are to consider irrigable lands.

First illustration.

In Kern County, where coarse, sandy land with porous subsoil and no substrata of clay or other impervious material except at great depth, may require the application of as much as ten feet or more in depth over the whole surface in a season, while the fine, compact, alluvial soils with subsoil of clay at depth of four to ten feet, may not require as much as one foot in depth during the whole year for ordinary crops. A given quantity of water would therefore irrigate ten acres of the latter class of land to one acre of the former.

Second illustration.

On the west side of the San Joaquin the shallow adobe soils with subsoils of hard-pan near the surface require much less water the first year than the deep, loamy soils, although the power of the latter to retain its moisture may diminish the quantity required in future, and increase the duty beyond that which it is possible for water to accomplish on the former.

(F)—The measure of water necessary to effect the irrigations changes on the same land in succeeding years.

Owing to peculiarities of soil, subsoil, and topographical shape, the measure of water required to irrigate some lands will change greatly with the lapse of time; so that any determined quantity will effect five, ten, or even fifteen times the irrigation duty on the same lands, after they have been under irrigation a series of years, as it will accomplish during the first and several succeeding seasons.

This fact also has a direct bearing upon the questions concerning the lands to which water should be distributed, where the supply is deficient, and the amount of water which will be required to effect the irrigations in the future.

First illustration.

When irrigation first began in Kern County, for example, it was found that not only the land upon which the water was immediately applied was wetted, but that the adjoining land for miles around was soaked. The ground was dry for ten, twenty, and sometimes thirty or forty feet. All this thirsty substrata had to be filled with water. Consequently, the first year it did not accomplish a higher duty than fifteen to twenty acres per cubic foot per second.

Constant irrigation and its gradual extension over wide areas has tended to maintain the lower strata in a moist condition. Without exact data to establish the assertion, it is probably within bounds to say that the average duty of water on the lands irrigated first in 1874, is now five times as great as it was the first year, and the duty is slowly increasing with the extensions of the system. Other soils of closer texture are not similarly affected, and in the case of alkaline adobe soils, after the second year's irrigation there can be little or no increase in the duty of water, except that which may proceed from an increase of skill and economy in its application.

Important Facts—Class II.

THE WATER SUPPLY.

(A)—The supply of water is short, and where irrigation is most needed must be economized.

Considering the quantity of water available from many of the sources of supply, in connection with the character and extent of lands requiring its application, and naturally dependent upon each of these sources, if such lands ever are to be irrigated, it appears that there is not enough to bring them all under irrigation, unless the arrangements for the distribution and use of the supply are far more perfect and favorable to its conservation than any which have thus far, except in isolated and restricted instances, been carried out.

This is a most important fact, having a bearing upon the general question as to what extent of lands can be irrigated from any source of water supply.

First illustration.

Let us take, for example, the rivers in the southern part of the San Joaquin Valley, where irrigation is essential to any success in agricultural operations. In Kern Valley there are about 475,000 acres of land which may be considered as susceptible of irrigation, and adapted to cultivation by artificial watering.

If this land is ever to be cultivated it must be irrigated, and the supply must come from Kern River as the main, almost the sole, source. To what extent is Kern River capable of irrigating this land? If we are to judge the capacity of the stream by its discharge in 1879, the only season in which its flow has been observed by this Department, when it delivered at the heads of the canals, during the first seven months of the year, barely sufficient to have covered 233,800 acres to a depth of one foot, allowing nothing for waste, we must conclude that a large proportion of the land can never be irrigated, for experience shows that even under the most favorable circumstances one foot in depth, when artificially applied, is insufficient to mature crops, except where supplemented by absorption from adjacent watercourses, and that three to four feet in depth is more nearly the average quantity now required per annum, or whether required or not, is applied. Fortunately, however, there is ample evidence to show that the season of 1879 was one of extraordinary scarcity of water, and that in ordinary seasons Kern River supplies very much more than the quantity discharged last year—say three times. But in the most favorable season to effect the irrigation of all the irrigable lands, the appliances must be more perfect than at present, and a less quantity of water used upon the lands. It would be necessary, in order to effect the end, to stop the waste of water in distributing ditches and in canals by puddling, and all other causes of waste would have to be eliminated to the greatest possible extent.

The constant increase in duty of water with the spread of irrigation on wider areas, and the saturation of large bodies of dry lands, that always require more moisture the first few years than at a later period, leads to the belief that in course of time, 2 and 2½ feet per annum will be the ultimate quantity required, and possibly, less. For cereals this will be applied during the months of November, December, January, February, March, and April. Now, during that period last season, Kern River discharged sufficient water to have covered 70,000 acres two feet deep, allowing 25 per cent for unavoidable waste in transit to lands. Corn and alfalfa are principally irrigated from April to October. In that period the discharge of the river, allowing 25 per cent for waste, would have covered 68,670 acres to a depth of two feet. Thus during the entire season 138,670 acres of the different crops might have been irrigated, if two feet in depth had been sufficient, and the waste did not exceed 25 per cent. The amount actually irrigated, was, however, but 38,800 acres, and all the water of the river was used, showing not only that much more than two feet in depth was applied, but the waste greatly exceeded 25 per cent.

Second illustration.

From the north line of Kern County, to a line midway between Kings and San Joaquin Rivers, the area of agricultural land on the east side of the trough of the valley is 1,319,155 acres, of which 775,000 acres (a little more than one-half) may be classed as in itself

susceptible of profitable irrigation. To give the latter area two feet in depth per annum, allowing 25 per cent for waste, would require 90,024 million cubic feet, giving a continuous discharge of 2,858 cubic feet per second through the year. The observations of this Department, however, show that from November, 1878, to October, 1879, inclusive, the aggregate volume of the three principal rivers, Kings, Kaweah, and Tule, which must be depended on for more than nine-tenths of the supply, was but 64,937 million cubic feet, of which Kings River supplied 54,589 million cubic feet. The area irrigated by Kings River in that period was but 61,210 acres, and the amount of water diverted for that purpose was 29,127 million cubic feet. Of the amount diverted it is estimated that 20,690 million cubic feet, or 71 per cent, was delivered by the main canals for irrigation, the depth over the land ranging from 1½ to 27½ feet; the average on the whole area being 7.76 feet. These figures make it apparent that nearly 62 per cent of the water in the river did not reach the lands, and that the amount actually applied in irrigation was excessive and extravagant in the extreme.

(*B*)—*The supply of water is variable, and it should be equalized as far as possible.*

Considering the short time of duration and uncertainty as to period of flow of many of the streams looked to as sources of water supply, in connection with the recognized necessity for water at certain times —which may not be the periods of flush flow in the streams—it appears that either crops and methods of cultivation by irrigation must be selected with great wisdom, and modified to suit the uncertain circumstances of the water supply, or water must be stored for use when wanted; otherwise farming by irrigation will fail of success in a great degree, even where the actual aggregate supply of water is sufficient to insure a favorable result.

Illustration.

Take, for example, the water supply of Los Angeles and San Bernardino Counties. In winter, the streams frequently run full, when there is but little demand for water for irrigation, while through the irrigating season, in the spring and summer months, when the orchards and vines require water, the volume of supply is much diminished, and the streams dwindle and sometimes fail entirely, at the time when irrigation is greatly needed. In this case the equalization of water must be accomplished by storing the winter surplus.

Kern, Tule, Kaweah, and other rivers in the San Joaquin Valley, in many seasons carry far more water than can possibly be used by the existing canal systems, or any which may ever be built; and at other times do not flow in sufficient volume to supply even the present demands.

Were a greater area of land in these sections devoted to alfalfa, orchards, and vineyards, which require but little water after they become well started, the water supply could be made to go much farther, and the average duty of the supply greatly increased.

The storage of water in seasons of plenty, for those of drouth, is even a greater necessity than the adjustment of crops with reference to the water quantity required to irrigate them, and the regulation of the times of watering to the periods of flush flow in the streams.

(C)—Sources of water in some cases are inter-dependent, and conflicts of interest thus arise.

The diversion of water from some sources of supply materially diminishes the quantity available from others, but there are instances wherein the irrigation of some lands will doubtless materially increase the supply of water to be obtained for that of others.

Illustration.

In San Bernardino and Los Angeles Counties, the waters of which streams naturally issue from the Sierra Madre upon the high interior valley, sink and rise again in passing through the Coast Range of mountains, or upon encountering some impervious substratum elsewhere in their flow towards the sea.

The abstraction of water from a point high up on the river may, and frequently does, greatly diminish the supply at low water points, though oftentimes there is no apparent connection between the two and they are separated by miles of dry territory.

In such cases it would be exceedingly difficult to determine the measure of right at the two points, and they are mentioned in order that it may be seen how complicated the problems of water apportionment becomes, and how the irrigation of some lands may reduce the supply for others remotely situated. On the contrary, the irrigation of the high plain lands next the foothills along much of the east side of San Joaquin Valley, where the soil is pervious and underlaid with hard-pan, will in time, probably, render irrigation for cereals and all early crops almost unnecessary further down the slope—for the percolation will wet up the country under such circumstances far below where the water is applied, as proven by experience both in Tulare and Kern Counties, where the conditions, with respect to hard-pan, are not nearly so favorable.

(D)—The sources of water supply vary in character, and the same ruling in regulation cannot be made to apply to all.

The character of different sources of supply of water for irrigation varies greatly, the interests involved are more or less complex, and the differences do not admit of one mode of solution.

Illustration.

Water for irrigation does not everywhere come from natural streams. In Los Angeles and San Bernardino Counties the supply is largely furnished by springs, which either form independent sources or go to swell the volume of the streams at various points. The streams of that region, too, are peculiar. They sink and reappear again, losing water at some points and receiving more from other sources, each having individual characteristics which render it different from all others. Another extensive source of supply is furnished by subterranean channels through the medium of artesian wells. Now water regulations, applying to that section of the State, would not apply to the San Joaquin Valley, for instance, or to other localities where the water supply is wholly from large natural streams, some of them navigable.

Questions will certainly come up then in such variety that great circumspection must be exercised in framing an irrigation policy,

lest in considering one portion of the State another may be made to suffer.

(*E*)—*Irrigation interests conflict with those of riparian proprietors.*

The extent to which riparian ownership may restrict the diversion of water for irrigation from the streams is unknown.

Public attention has been so frequently drawn, of late, to the conflict between the appropriators of water and the owners of lands bordering upon or naturally irrigated by the streams in the southern half of the State, that it is not necessary to illustrate this fact by the citation of any instances.

Suffice it to say that there is not any one irrigation region of importance in the State where troubles of this kind have not arisen, and there exists most unsettled and unfortunate conditions of affairs on this point, which have retarded the development of irrigation property more than any other one fact.

(*F*)—*Irrigation interests may conflict with those of navigation.*

The extent to which water may be diverted from the upper streams, without materially affecting the navigable qualities of the rivers in their middle and lower courses, cannot be estimated at this stage of the inquiry, and it may depend upon the engineering treatment which they receive in the efforts to improve their flood-carrying capacity and their low water condition for navigation.

Illustration.

The San Joaquin Valley streams will doubtless be called upon each year to give up to the irrigation canals derived from them a large part of the water they bring out of the mountains, at all times, except during the freshets of winter and the great spring rise which is occasioned by the melting snows, at which times the volumes presented may generally be enough in excess of the probable capacity of the channels of diversion, and the absence of the amounts diverted may not have an appreciable effect upon the depths of streams below, if their low water channels are brought to an uniform standard of width according to grades.

There are instances on record where the diversion of water from rivers has not materially diminished the quantity present in the channel some miles below; and it may be that such would prove to be the case with our navigable California streams, the Sacramento and San Joaquin; but we have no assurance of this whatever.

In the case of certain rivers in the north of Italy—in the valley of the Po and tributary to the main stream—in very dry seasons their entire volumes have been abstracted at points high up on their several courses, without diminishing the amounts flowing in their channels at points miles below. And let it be remembered, too, that these are large rivers, as compared to the San Joaquin and its tributaries.

Nevertheless, it is an equally well known fact that the great plain through which these rivers run is underlaid by a thick stratum of gravel and sand, which is a vast reservoir of water, giving forth its supply in numerous natural artesian wells, known as *fontanilli*, all over the country, in great numbers.

As these rivers run on this water-bearing stratum, the abstraction

of their supply above removes a pressure in the channel, which is responded to by a fresh supply appearing from the underground stream, as it were.

And the same general conditions are found to be present in those quarters in India where similar results have been noticed.

There is no knowledge at hand of the geological formatiom of the great valley of California which will justify a definite opinion one way or the other, on this point.

If the plains are underlaid with water-bearing strata cropping out in the trough or under the streams, we may expect results similar, in some unknown degree, to those referred to: the abstraction of water for irrigation will not interfere with the interests of navigation.

If, on the contrary, such is not the physical fact in the case, an opposite result is to be looked for, until such time at least as the plains above shall have become thoroughly saturated with water, and begin to give out the surplus of that held in the soil overlying the impermeable hard-pans known to exist, and this time cannot arrive for some years after irrigation becomes generally prevalent.

There is but one thing certain about this matter, and that is, the result is uncertain, and complications should be guarded against.

Even now, there are continued complaints on the part of those interested in the navigation of the San Joaquin River, that the abstraction of water for irrigation purposes seriously affects the depth of the stream above the Tuolumne or Merced, and such important matters should not be allowed to go without proper State examination, until they culminate in suits at law, or, as in some cases, in acts of violence.

A study of the tables embodied in the last chapter and the apportionment of water as therein contained, is instructive upon this point. It must be remembered, however, that these results are the outcome of but one season's observations, hastily made, with a multitude of other duties demanding attention.

Important Facts—Class III.

APPROPRIATION AND USE OF WATER.

(*A*)—*The claims to water sometimes equal or exceed the supply.*

A large portion of the water supply of the perennial streams adjacent to the regions where irrigation is most needed, is already claimed by private appropriators.

First illustration.

There are in all 83 claims to the waters of Kings River on record, of which 60 are on file in Fresno County, and 23 in Tulare County. Of those in Fresno, 28 are somewhat definite in their statement of amounts claimed, the aggregate of which is the equivalent of 14,176 cubic feet per second, and in Tulare County 14 claims in like manner represent 9,723 cubic feet per second. The total amount thus claimed is 23,899 cubic feet per second.

Allowing for duplicates, as hereafter explained, it may be said that there stand on the records of the two counties mentioned claims somewhat definitely expressed to the waters of Kings River to an aggregate amount of 20,000 cubic feet per second, besides many others indefinite and extravagant in their nature.

The maximum discharge of Kings River for the year 1879, was 9,030 cubic feet per second, the minimum discharge 210, and the mean discharge for the year ending October 31st, 1879, was 1,731 cubic feet per second.

From this it appears that the aggregate amount of the *comparatively definite* claims on record exceeds by two and a half times the maximum discharge of the river during the period mentioned.

It is true that many of these claims have not been "made good" by appropriation and use; but they stand, and for the most part uncanceled, unchallenged, save in the minds of men, until adjudicated as questions come up before the Courts.

It is also true that this last has been a season of short water supply, but even in a year of ordinarily large flow the result would be little altered.

Second illustration.

The nine principal canals which take water from Kings River have claims aggregating 6,595 cubic feet per second. The flow of water in the river where it leaves the mountains during the past year, ending October 31st, 1879, was as follows:

Average for the first three months	321 cubic feet per second
Average for the second three months	2,694 cubic feet per second
Average for the third three months	3,557 cubic feet per second
Average for the fourth three months	384 cubic feet per second
Average for the year	1,731 cubic feet per second
Maximum average for one month	5,496 cubic feet per second
Maximum average for one day	9,030 cubic feet per second

Thus, the gross amount of the claims of these companies exceeds by nearly 100 per cent the average flow of the river through the three months of maximum supply for the season observed.

Third illustration.

One canal company, the Fresno Canal and Irrigation Company alone, has a claim to 2,700 cubic feet of water per second from this river. The comparison of this single claim with the above exhibit of discharge will be instructive.

Fourth illustration.

There are in all 76 claims to the waters of Kern River on record, whose aggregate volume, as nearly as they may be estimated, is 24,917 cubic feet per second, exclusive of claims not on record. Of these there are claims which are either known to be abandoned or are duplications of each other to the extent of about 13,535 cubic feet per second. Those which are regarded as in full force, aggregate 11,382 cubic feet per second. There are several canals constructed prior to the passage of the Appropriation Act of 1873, claiming certain indefinite amounts, by priority of appropriation, but which have no claim on record. Estimating these by their maximum capacity, the only criterion we have, their aggregate is 505 cubic feet per second.

The maximum discharge of Kern River for the year 1879 was 1,231 cubic feet per second, the minimum discharge 146, and the mean discharge for the year ending October 31st, 1879, was 485 cubic feet per second.

(*B*)—*But few claims, if any, have been made good to their full extent by appropriation and use.*

Although in many instances the aggregate amount of the claims to water exceed the volume of supply, the amount of water actually diverted is generally much less than that claimed.

First illustration.

The nine principal canals which draw water from Kings River have an aggregate maximum capacity of 1,870 cubic feet per second. That is they cannot take all combined more than that much water from the river, and lead it out upon the plains to where their channels are between good banks (not even so far as where irrigation commences), yet the total amount of their claims to water, as before said, is 6,595 cubic feet per second. These are old claims—all but one of them having been in existence some years.

Second illustration.

One canal drawing water from the river claims 2,700 cubic feet of water per second. Its maximum capacity to carry water out from the river bottom land (there being no irrigation on the way) is 500 cubic feet per second, yet there is of record certain testimony to the effect that this canal, at a particular time when examined in 1874, had 1,312 cubic feet of water per second flowing in it. The fact is that it has since been enlarged to its present maximum capacity of 500 cubic feet per second.

Third illustration.

Six of the largest canals of Kern County, having claims to water on record, have a total maximum capacity of 1,400 cubic feet per second, while their aggregate claims exceed 3,950 cubic feet per second. One of them claims an amount equivalent to about 1,120 cubic feet per second, while its capacity is less than one-fourth that amount, or 250 cubic feet per second, and indeed the canal has never carried even that much water.

There are several canals having extravagant claims recorded, which have been made good, so far as to comply with the law in the matter of commencement of work, etc., but which consist merely of a head-gate, and a short cut leading therefrom into some natural slough. They are prepared to divert water, but they are not prepared to use it for irrigation, although they may be intended for that purpose at some future time.

There are other filings on record which modestly claim all the water of Kern River, Buena Vista, Kern, and Tulare Lakes, and all the sloughs and streams leading into them. It is unnecessary to state that these claims, although on file, are void, as no steps whatever have been taken to perfect them.

Fourth illustration.

There are instances where location of dam sites, head-works, and

canal routes have been made at commanding points in the topography of the streams. Some work has been done, and a little, but very little (perhaps the labor of one man) is being carried on almost continuously, with the view of holding the privilege of diverting water at the points spoken of, and to large amounts. Now, as these are the most favorable localities for diversion, and there could scarcely be an avoidance of them, it follows that such proceedings do not have the appearance of bona fide appropriations, for although much water is claimed, little or none is used.

(*C*)—*The extent of the rights to water not definitely known.*

The present water right laws are exceedingly loose in their provisions, and their operation creates confusion on the subject of the water supply.

In very many instances the extent of the desired right is not definitely or even intelligibly expressed in the original appropriation papers, nor is there any subsequent record whatever of the amount of water actually appropriated and used.

First illustration.

Of the 83 filings of claims to water in Kings River only 42 are expressed so as to admit of interpretation into definite sums, even approximately. The remaining 41 are so indefinite that their equivalent amounts cannot be estimated. Several of them set up a claim to all of the water in the river. There are claims filed in Tulare and in Fresno Counties also, but these duplicate filings cannot always be recognized.

Second illustration.

Frequently it cannot be told for what canal a claim is made, or, conversely, under what name the claim to water for a certain canal has been filed. The owners of the canal, or directors of the company owning it, or some of them, sometimes make a filing for water in their own names, and do not specify the work for which it is intended, or the location where it is to be diverted from the stream.

In the case of the Grant Ditch and Murphy Slough water claims, for instance, on lower Kings River, there are no filings which can be fixed upon as applying to these, though doubtless there are records in some one's name intended to cover the claims. And, in the case of the Sutherland Slough water claim, there is no filing specifying this slough or ditch as that to which it applies, although there is a claim filed by John Sutherland, but without a definite locality or purpose expressed in it.

Third illustration.

New filings are sometimes made for water for a work, and it is not specified whether the amount of the filing is to be regarded as in addition to that already claimed, or whether the excess only (if any) is to be thus taken. Instances of this character are too numerous to mention.

Fourth illustration.

The most unintelligible filings exist with respect to water claims, as, for instance, one filing in Kern County calls for "sixty cubic feet

of water," without stating whether that amount is expected to flow in a second, a minute, an hour, or a day; another claims sufficient to irrigate a certain area of land; another claims "sufficient to fill a canal of a sectional area of 160 feet, with a fall of two feet per mile;" another claims "flowing water to the extent of 300 cubic feet, measured under a four-inch pressure;" another claims "60 feet of water, measured under a four-inch pressure;" another claims "the amount that may be conveyed in a canal 12 feet wide by one foot deep, having a fall of three feet per mile;" another claims "18 cubic feet;" another claims "50 *cubit* feet, measured under a four-inch pressure." There are several of this class. Another claims "50 feet of water flowing under a four-inch pressure;" another claims "30 feet of water for irrigating and agricultural purposes." Others claim the right to take out a ditch of a specified size, without stating the amount of water claimed. Another claims water "to the extent of 1,728 inches," without specifying whether they are cubic inches flowing in a given time, or square inches flowing under a stated pressure.

The generality of claims to the waters of Kern River are expressed as required by law, in "inches measured under a four-inch pressure." The whole amount of the claims of this class now supposed to be in force were equivalent to about 10,700 cubic feet per second.

With but few exceptions no mention is made in the filings of the name of the canal to which they are supposed to apply, and it is only by the most careful inquiry that one can identify them or ascertain to what particular work, either constructed or proposed, they are presumed to belong.

(D)—There is no recognized standard of measurement for water.

Even when expressed in legal phrase "inches under a four inch pressure," there can be no convenient method devised for directly measuring any large body of water in these terms, and consequently there is seldom any definite knowledge, even on the part of the owners and managers of ditches, of how much water a ditch will carry at different depths of flow and *how much has been appropriated.*

First illustration.

The "inch," or "miner's inch," so called, is the nearest approach to a standard measure of water yet adopted at all generally in the State. But it is not practicable to construct large regulating works upon the principle underlying the method of measurement to which this expression applies. And, furthermore, within the range of practice, the method is intricate; for the slightest variation in the dimensions of the measuring device or work, brings with it a material change in the rule to be applied in interpreting the results had therefrom; and such modifications are so numerous and varied that the reduction of results to a common standard becomes an endless job.

Thus, the miner's inch being interpreted as used, by means of various measuring boxes in different parts of the State, in distributing water from ditches, gives results ranging from about 1,800 to 2,600 cubic feet in 24 hours—a variation of nearly 30 per cent. of the larger amount; and this, when water is measured on a small scale, in distribution.

There is absolutely no standard in measuring water as distributed

from streams to the canals. The head-gates are of shapes and dimensions to suit the fancy of those who construct them, and in four cases out of five the intake is not known, even approximately.

It must be apparent, that under such circumstances, conflicts will arise in distributing the water to the claimants thereof; and such conflicts will never cease, if we are to credit the accounts of experience in other countries, until the distribution is conducted under State regulations with a recognized standard of measurement.

(*E*)—*Many existing works are wasteful of water.*

In many instances, owing to faulty location, improper and insufficient construction of works, and improvident management of them after construction, an unreasonably large portion of the waters diverted from the rivers is not employed in useful irrigation, but is lost from the main canals upon the plains or in the swamps through which they pass, and is wasted by evaporation and percolation without profit to any one.

First illustration.

One canal in the San Joaquin Valley, leading water about 30 miles out into the plain, may be taken as an example of loss of this kind. For at least 16 miles of this distance the upper bank of the canal is defective, and at points the water flows out upon the plains, where it stands in wide sheets, covering a large area of land, and is rapidly absorbed by the soil and evaporated into the atmosphere. The loss of water from this canal is very great. When gauged on one occasion, of 90 cubic feet per second passing through its lower head-gate, only 14 cubic feet per second reached the lower end of the canal, 28 miles away, yet there was not any being used along the route, but it was wasting it at a number of points.

The canal was in this state when examined on several occasions during the season of 1879, and it had been in the same condition for several years. Although it is true that the character of the soil along its route is unfavorable to the perfect maintenance of its banks, yet this can be done, as evidenced by the lower bank standing.

The work can be kept in such repair as will probably save half the water lost, though it may be expedient to relocate it for several miles of its route to avoid low spots and others of peculiar soil composition.

Second illustration.

A canal taking water from Kings River, at one point on its route passes through a low piece of ground in the plain, and its waters spread over about 60 acres of territory, where great loss is suffered by evaporation and percolation.

On one occasion when examined, of 310 cubic feet per second which entered this swamp, 92 cubic feet were lost, and only 218 cubic feet found its way into the ditch below. The canal was in this condition when examined on a number of occasions during the seasons of 1878 and 1879, and had been in the same state since the time of its construction some years previous. There is no difficulty in avoiding this principal point of waste, by changing the route of the canal for about two miles.

The above illustrations are extreme cases, but many more could be

cited where, though less pronounced in their character and location, the losses of water are very great, and the conditions capable of ready remedy. A careful reading of the special reports and tabulated data annexed will be instructive on this point.

It will be observed that names of canals are not mentioned in the above examples. I have omitted them for the reason that when the State determines to stop the waste of water it will be time enough to say that which may affect some private interests.

(F)—The methods of applying water in irrigation are not economical of the supply.

In a still greater number of instances, owing to unskillful or insufficient preparation of the ground under irrigation, a large amount of water is employed without effecting the full measure of benefit which is properly due from it; and this, of course, to the detriment of those who would use the surplus of water if they could get it.

First illustration.

It is the practice with many irrigators to flood their lands until the water stands thereon to a depth of 6 to 18 inches, until it is absorbed by the soil or evaporated; and this is kept up after the soils have become well soaked and settled down by several seasons of waterings.

The practice is most prevalent amongst irrigators of small tracts which are divided up into rectangular patches by systems of little levees, one to two feet in height.

There should be proper drainage provided, and the surplus water drawn off as soon as it covers the ground.

This practice grows out of a bad system of distributing water; not a defective system of works, particularly, but a bad system of apportionment of the supply.

Where the irrigators hold what are termed "water rights"—a claim to sufficient water to irrigate their land from some company or canal which has appropriated and brought the water out for distribution—there is generally no established rule as to rotation and amount in distributing the supply, the superintendent of the work exercising his discretion in the matter. Under these circumstances, the irrigators have learned by experience that their supply is uncertain, and when they do get it they use all they can, and give their land what they term a "good soaking," in the manner above described. Now this is wasteful, and not beneficial to the land.

The duty in irrigation which a given quantity of water will perform is found to vary greatly, and although there are many circumstances which affect the result, as elsewhere explained, there are none which are so potent as this of the method of preparing the lands and applying the water.

Second illustration.

Where the class of cultivation is of a high order, as at some points in San Bernardino and Los Angeles Counties, particularly where fruits, vegetables, and vines are generally grown, the cubic foot of water per second constantly flowing throughout the irrigation season, and delivered at the land where used, is found to irrigate as high as 300 acres, and this without such extra appliances as pipes or troughs for distribution. But the water is measured out to the irrigator; he

prepares his land well to receive it; he takes as much as is necessary, and no more, and he is careful in the use of it.

Whereas, at some points in the San Joaquin Valley, where, as said heretofore, "water rights" are held from the company, the same quantity of water delivered to the irrigating community does not effect more than one-tenth the duty. But here the water is not measured out; the irrigator has a "water right," but he does not know *when* he will get more water, and each time he does get it, he naturally takes all there is to be had.

Now, the difference between the irrigation duty of the water as applied at these places, is due in part also to the variation in character of soils; and although this circumstance would have acted strongly against the San Joaquin lands spoken of, when first brought under irrigation, they have now been watered so long that the soil absorbtion has become very nearly equalized with that in the instances mentioned where a greater duty of water is obtained.

Nor can the discrepancy be attributed greatly to the difference in crops cultivated, for these are much the same in both localities referred to, viz.: large and small fruits, vegetables, corn, alfalfa, or clover. The only difference being that alfalfa, which requires the most water, is more cultivated in the San Joaquin example cited, but still not to so great an extent as to nearly account for the variation in duty of the water.

Third illustration.

When the Kern Island Irrigating Canal was first opened for use, water was sold to the irrigators by the acre irrigated—that is, each was furnished all the water he required through the season at a certain fixed price per acre. One year's experience convinced the canal owners that this system was too wasteful to be of profit. The farmer had no incentive to be economical of the supply, and applied water with lavish prodigality. A system of selling water by measurement was therefore devised, and has proven so satisfactory that it is still in use. By this means the farmer becomes directly interested in making a small amount of water go a great way, in order to reduce his water bill, and thus the canal is enabled to perform a constantly increasing duty.

(*G*)—*Water is lost in great quantity by attempting to deliver and use it at widely distributed points.*

In several notable instances water, after being diverted from the rivers, is conducted long distances, 5 to 20 miles, through lands requiring irrigation, and is distributed to widely separated tracts beyond, at loss from evaporation and percolation on its long course of a large part of the quantity taken out of the natural streams.

First illustration.

The three canals taking water out of Kings River on the north side, near where it comes from the mountains, furnish examples of this fact.

In the case of the Fresno and Kings River Canal, for instance, water is conducted through 28 miles of canal—these being two main branches for the last 6 or 7 miles—to irrigate 1,500 to 2,000 acres of land, scattered in small tracts along its route. The highest figure

represents a strip only about 350 feet in width on each side, of the 22 miles of canal, at least, along which it should be distributing.

The Fresno Canal water runs through 63 miles of main and principal branch ditches to irrigate 8,500 to 9,500 acres only. This amount of land would make a strip, on each side of the 60 miles of ditch, from which irrigation should be going on, but about 615 feet in width.

Now, both of these canals are old established works, amongst the oldest of the larger works in the San Joaquin Valley, yet the average duty of the cubic foot of water per second, flowing throughout the season, was only 22.5 acres for the Kings River and Fresno, and 32.5 for the Fresno C. and I. Co.

The Centerville and Kingsburg Canal is the third one of those spoken of. It is a new canal, comparatively speaking. The duty effected by each cubic foot of water per second flowing into it on the average throughout the season, was to irrigate 25.5 acres. From the fact of its being a new work, distributing in a new and dry section, its duty was good, as compared to that of the others.

All together, these three canals took in about ten and a quarter thousand millions of cubic feet of water during the year ending October 31st, 1879—enough to cover the area regularly irrigated by them, 18.16 feet in depth, or to cover 266,000 acres one foot in depth.

The very small duty which the water did accomplish, is due largely to the fact that it is so widely distributed; the loss in transit from the river is immense.

If the country through which the ditches pass was irrigated and cultivated, the loss would not be nearly so great.

There are other reasons for the small duty in these instances as explained in several other places in this report, more particularly under the next heading (H); and for more specific statements I refer to the special report concerning irrigation from Kings River, in the appendices.

There are instances of this kind among the canals of Fresno County, but the chief cause of waste there is in the division of water of Kern River among so many works. To reach the canals on the lower course of the stream a large amount of water is lost in the thirsty lands of the broad, shallow river bed. The irrigated lands are widely scattered over the plains, and in reaching the isolated tracts away from the river, almost as much water is lost as is used.

(H)—There is great loss of water as the result of an unnecessary duplication of works.

In other instances, several—three, four, or even five—comparatively small canals have been constructed to serve one region of country with water, which one main canal of moderate dimensions would abundantly supply more efficiently, at less expense, and at far less loss of water in transit from the river to the lands.

When water which might be carried in one channel is divided between two, and conducted through the same region even, the amount of loss from the two channels will exceed that which would result from the one.

First illustration.

In Appendix C will be found an example, wherein it is shown that the loss from two canals in Fresno County is nearly double what it would be from one calculated to carry the same amount of water. Now this is a very large item, and there are three main canals coming out from the river in the region mentioned, whereas one would be all sufficient; and it is safe to say that one half the aggregate length of branch canals and main distributing ditches now in existence, if properly arranged, would deliver the water at the points where it is now used—widely scattered though they are.

Second illustration.

There are five ditches taking water from Kings River for the irrigation of the Mussel Slough region. One canal with distributing ditches should do the entire duty, and it would do it with far less waste of water. These ditches cross and re-cross each other in great confusion—the total mileage of them is probably twice as great as it need be, and the evaporable surface of water exposed excessive, in the same ratio.

Third illustration.

There are now 23 canals and ditches regularly drawing water from Kern River, and a number of others which have established rights, and occasionally tap the stream, where four or at most six large canals, properly located, would amply serve the purpose with far greater economy of construction and maintenance, and with very great saving of water.

(*I*)—*Want of skill and care, on the part of the irrigators, results in an undue use of water.*

There is a great absence of knowledge of means and methods in the practice of irrigation and the art of preparing the ground therefor, and as the cultivator can only make up for his want of skill by the free use of water, a great waste thereof results from this cause.

First illustration.

This source of loss is ever present in every country where irrigation is practiced, and it must be expected, where irrigation is but just commenced, that the farmers not only lack the knowledge necessary in preparing the land but the skill in handling the water, and do not appreciate the necessity for extreme vigilance. It is certainly the case in many parts of California. Those who have attempted wet farming on a large scale, by the employment of day laborers, have realized how difficult it is to get hands who will undergo the discomforts inseparable from conducting the irrigation of large fields, and what litle hope there is of procuring any who possess a real knowledge of the art, or will acquire it readily.

And a greater amount of labor is required to irrigate with a small supply of water than with an abundance, for it must be husbanded and led over the ground by skillful manipulation.

Furthermore, to make the most of a supply of water it must be tended day and night. The canals cannot remain empty at night, nor must the supply go to waste. This necessitates labor in the field the twenty-four hours around—with night shifts of hands, of course—

a class of duty to which farmers and laborers in California are not accustomed.

It is not at all astonishing, then, that water is not economically used, from both these causes:

First—The farmer will not spend money for labor if he can succeed with less labor and more water (provided he does not pay for water by measurement); and,

Second—He cannot always get the labor to do the duty as it should be done.

Second illustration.

It is not necessary to pursue this point much further; I cite, however, a formulated statement of the use of water in irrigation as contained in one of the Indian professional papers on Engineering. The author, Mr. J. S. Beresford, in the employment of the Indian Government, and doing duty on the irrigation works, says:

"Each cubic foot of water entering the head of the canal is expended as below:

"*First*—In waste by absorption and evaporation in passing from canal head to distributary head.

"*Second*—From same cause in passing from distributary head to village outlet.

"*Third*—In waste from same cause in passing along village watercourse to field to be watered.

"*Fourth*—In waste by cultivators through carelessness, in not distributing the water evenly over the fields, causing evaporation and the ground to get saturated to an unnecessary depth in places.

"*Fifth*—And what is not thus lost is used in useful irrigation."

The author then goes on to show that the actual duty of the cubic foot of water per second, flowing for three months, was the irrigation of 140 to 190 acres, whereas, it might be brought to 300 to 500 acres—according to circumstances—if the unnecessary losses were stopped, and he ranks the loss from the inefficiency of the cultivator as a principal one. This is the experience in a country where irrigation has been practiced partially for ages. It cannot be expected that the result will be otherwise here, unless there is some supervision of the use of water, some steps taken to show the cultivators their errors, and to *prevent waste* at least, if not undue use.

(J)—The use of water for stock purposes, according to the customs of the past and present, is extravagant and wasteful of the supply.

There have been, and are instances, where water is used in the irrigation of natural grasses for stock feed, with little or no preparation of the lands to receive it, and with a very limited amount of care taken in its distribution and conservation, so that a great waste thereof is suffered.

First illustration.

The low lands—those generally subject to complete or partial flooding by each recurring ordinary high flood—in the upper San Joaquin River region, and those still further up the great valley, between the San Joaquin River and Tulare Lake, and thence bordering the lake and stretching onward to Kern and Buena Vista Lakes, are owned or

occupied generally by persons engaged in rearing cattle for the markets.

These lands have been sought after as the most desirable for stock range. In the natural order of things they are well watered in each year of ordinary high flood, and in such seasons they abound in many convenient drinking pools and produce luxuriant pastures, which remain green and growing long after the higher plain lands are rendered parched and naked of feed and water by the summer's sun.

As the benefits of a more systematic irrigation have become apparent, the owners of such stock ranges, alive to their interests, have found it to their advantage in some instances to supplement and assist nature's action in spreading the water over their pasture lands. Years of comparative drouth occurring, these pastures suffer also, as the waters do not rise sufficiently high to flood them thoroughly, and thus the efforts to irrigate them have been stimulated; and once the work begun. it has been extended to somewhat drier lands—those which in nature are seldom flooded.

It will not pay, perhaps, to incur expense in preparing such irrigation fields to that extent which would be necessary to make possible a reasonable duty from the water, nor would it be admissable, from the point of view of the stock raisers' business, to employ that care and exert that skill in distributing the water in irrigation which would insure such reasonably large duty. At all events the lands are not so prepared, and the water is not so used as to give promise of anything but an outcome extravagant of the supply, and lay the foundation for a wasteful practice which it may be difficult in the future to eradicate.

By such a system the water is led out upon lands of uneven surface, not prepared with proper checks and distributing ditches to receive it, and is allowed to run over its surface, for the most part, as best it may. Thus it takes a great quantity of water to reach any considerable part of the land, and it then collects in the low places, where it is not drawn off to irrigate other lands, but is suffered to remain and evaporate or soak away into the soil throughout the summer.

This is a picture of irrigation of the most crude order. It can well be understood that claims to water used in irrigation of this kind are in existence, and may grow up as time goes on without regulation in such matters.

Second illustration.

In the case of low lands, in the regions mentioned during the course of the previous illustration, which have received waters spreading from the main streams throughout each year almost, it is now becoming apparent that the diversion of these waters for irrigation of the plains above, causes the ponds to go dry and the pastures to become parched.

Naturally enough, the stock raisers, being inconvenienced, to say the least, complain, and have appealed to the Courts for redress, claiming, as riparian proprietors, the right to have the waters flow into their swamps and the pools thereof, *as by nature designed*, for the irrigation of their pastures and the watering of their cattle.

It is hardly necessary to point out that if the same pains were taken and the same expense incurred to irrigate these pastures that is taken and met to impart fertility to the dry plains above, by the use of the

water, a much better result would be obtained with a far less consumption of the supply; and it is equally apparent, if water were systematically and regularly conducted to ponds large enough, but not extravagant in dimensions, and not of unnecessary number, the cattle could be supplied with it for drinking purposes at far less loss by evaporation and percolation than now occurs. It is safe to say that to wet these swamps as nature irrigates them, and to water the stock as it is done by the same lavish hand, at least three, and perhaps six, and sometimes ten times the amount of water necessary for the purposes is consumed.

In view of the two foregoing illustrations, I am justified in saying that the use of water for stock purposes, according to the customs of the past and present, is extravagant and wasteful of the supply. Whether *the right* exists for such use or not is another thing.

(K)—In the location of irrigation works the necessity for drainage has frequently been overlooked.

In very many instances irrigation works have been located and constructed without any view to proper drainage of the lands watered, and the result will inevitably be—when the soil and subsoils shall have become thoroughly wetted and settled down—a serious if not alarming impairment of the healthfulness of such irrigated regions.

Illustration.

It is a favorite measure of economy with the ditch builder of little experience and knowledge of the results of practice elsewhere to adopt some line of depression in the land—some creek or old slough channel—as the route of his leading canal. He has heard of engineers advocating the location of canals and ditches along the higher ridges of land in the plains, and he sees that thus placed the works will cost more at first than if natural channels were used in which to conduct the water.

He has, possibly, seen some instance of water led for mining purposes from a source of perennial supply into and along a natural creek bed, whence to be taken out at some lower point for use. Applying the same principle in projecting an irrigation canal, he announces his discovery of the fact that an unnecessary expense is incurred when a canal is constructed along the higher ridges of a plain.

To men about to undertake the construction of a ditch to aid in irrigating their lands, with limited means at command, and that earned by honest toil, such an announcement is captivating. They know nothing whatever of the underlying principles in such matters, upon which alone permanent prosperity may be assured; they know nothing of experience, elsewhere in irrigation—experience, I mean where the art has been practiced for a term of years—they are good agriculturists, from some western or middle State, where water falls directly on the land from on high, they have had no experience in irrigation, or the location or construction of works therefor, and their reading has been in other channels of knowledge.

The ditch builder who proclaims his cheap method of "getting the waters out," is hailed by them as a benefactor. He starts a company; they subscribe for the stock, and the work goes on. The water is "brought out;" the lands—before a desert almost—become green

with verdure, and good crops are raised. Such is the picture for the first year. The second is just as bounteous in its returns, if not more so, and the third perhaps also yields up an abundant harvest.

The time soon comes though—according to the circumstances of soil and subsoil, water supply, and extent of dry land to be wetted—when it is found that the crops will not all mature; the ground is so wet when harvest comes that the animals cannot be driven over the fields in places, nor the reapers drawn along to gather in the yield. This is remedied for a season or two, by keeping the water out of the ditches for several weeks or months before harvest time arrives. Then commences contention. Some subscribers to the association have crops on land which becomes too wet; they want the water supply stopped early in the season, to give their crops a chance to mature. Others have lands which do not become supersaturated; they want the supply continued to keep their crops growing—crops perhaps of another kind which require water until a late part of the season. Others still find their lands become permanently so wet that they do not want water in the ditch at all during the year.

Malarious fevers appear, and crops fail entirely, as troubles in addition to this harvest of contention, which is now brought to the doors of these well meaning and industrious people. "Irrigation is a failure! It is a curse to the land! Better live on the dry plains and raise a little of this, and a little of that, than to have such a condition of affairs as is found in such and such an irrigated region!" Of this character is the cry that goes forth from some source equally inexperienced with that from whence has come the state of affairs bewailed.

Now, why is this? Because the depressions in the plains, those lines of topography which by nature are designed as drainage ways, are used as channels of water supply, and the soil of the surrounding lands becomes saturated from below.

Were irrigation properly applied from works located as they should be, and under such restriction as have been found necessary in older irrigation regions, such would not be the case. The water would be brought to the soil in which the roots of the plants to be sustained actually are—the soil near the surface—before the ground became supersaturated, and the surplus would find a ready exit in a great measure through the natural drains of the country, probably to be taken up again at some lower point, and there used in irrigating more land. This would be irrigation admitting of an economical use of the water supply, and insuring against the disastrous effects upon the health of communities, which always follows where drainage is not attended to.

I have endeavored to draw an illustration of irrigation without regard to drainage, and to contrast it with the outcome of process properly practiced. Both results are to be realized in California. They are now almost ready for inspection. Is it good policy for this State to permit the use of water, and the acquirement of right to divert it from the stream, under conditions which will realize the dark picture?

Under certain circumstances natural depressions or creek beds may be used as conducting channels permanently, without bad effect, for a portion of their routes, but the instances are not many. There are more instances when they may be used for a few years—a very few

years—until the plain is well watered, then to be abandoned to their natural function as drains, and supplemented by artificial drainage ways also, while channels of water supply properly located are built. Other instances of the effects of bad drainage are cited in the second chapter of this part of my report under the head of *Irrigation from Mining Ditches.* It will be seen that these matters require regulation.

CHAPTER V.

CONCLUSIONS AND RECOMMENDATIONS.

At the opening of the preceding chapter allusion was made to the three questions which first present themselves in the conduct of an inquiry into the subject of irrigation. Certain important facts having a bearing upon one or the other of the questions were then announced and illustrated. It now remains to show the general bearing of these facts upon the outlook of irrigation, and thus their connection with the problems with which the State has to do, and consequent influence which they should have upon State policy towards this interest. But before proceeding to this duty, I call attention to one other matter of importance, viz.: the necessity for an irrigating population to insure the success of irrigation enterprise.

Population Necessary.

I have before alluded to the proposition that a great increase of population must in California accompany or closely follow upon the construction of irrigation works to insure the success of such enterprise.

Population in India, Italy, and Spain.

The population of the districts in India where irrigation has been most successful, ranges from two hundred to six hundred persons per square mile. Over certain large divisions of that land, each embracing several irrigation districts, the average population ranges from three hundred to five hundred persons per square mile. In Italy we find an average of two hundred and seventy persons for Piedmont, and three hundred and ninety persons for Lombardy, the two great irrigated provinces of the Kingdom. The irrigated sections of Spain have populations ranging in number from two hundred to four hundred and thirty persons per square mile over large areas.

Population in Egypt.

Egypt proper has a population equivalent to four hundred and eighty-four persons upon every square mile of her cultivable territory; and the irrigated portion (only two-thirds of the total area cultivable with irrigation) is much more densely populated than that which is not. It has been a serious question with the Egyptian Government in considering the propriety of extending its system of irrigation works over the remaining two and three-fourths millions of acres of the culturable lands in that country not yet watered, whether there would be population sufficient available to farm those lands when irrigated, and this, too, when there are nearly six millions of people on Egyptian soil, the greater portion of whom have been raised to irrigation methods.

French and British experience.

When the French Government had constructed irrigation works

in Algeria, at the expense of millions of money, she had to import irrigators from Spain to use the water and make the works profitable. The British Government is learning in India now a lesson which should not be lost upon us—a lesson which is costing it hundreds of thousands of dollars annually, which might have been saved by a little less haste and a little more consideration before constructing so many irrigation works.

An irrigation population necessary.

We are to infer from the statistics and circumstances cited, that it will be necessary to have from 100 to 150 people at least per square mile, on the average, over our irrigated territory, including villages, notwithstanding our improved methods of farming by the use of machinery, and that a large proportion of those people shall be farmers skilled in agriculture by irrigation, before the practice of that art can be successful over any considerable portion of the State. This will make nearly a million of people in the great central valley between Red Bluff and Bakersfield.

The future of irrigation.

It will not do to say that no such population exists now on lands cultivated by irrrigation with profit in those sections. That great valley can not be farmed as the portions are which are now under irrigation. Crops must be diversified, new products introduced, which will take far more labor than alfalfa and grain do in their cultivation. And the waste of water which is now prevalent upon these crops must be stopped, by expending more labor in its distribution, if we are ever to bring the standard volume of a cubic foot per second to its ultimate duty. When large districts of country are brought under thorough cultivation by irrigation, the agriculture there prevailing will be an art quite different from farming as now practiced in any portion of our Union.

The fourth problem of irrigation.

Irrigation in California means immigration; and it means not only cultivation of crops, but also cultivation of irrigators. The question, *How to secure a population of irrigators,* may be regarded as presenting the fourth great problem of irrigation.

PRIMARY CONCLUSIONS AND OPINIONS.

I now ask attention to certain conclusions which I have been brought to in the study of this question. These, though foreshadowed in what has already been said, are here categorically presented, verified, and then connected with some recommendations which are to follow:

(*A*)—*The progress in the construction of works of irrigation must be gradual—as the country fills up with people.*

Irrigation can only be extended over any considerable portion of the great area of lands yet unwatered by degrees. As the water supply is developed; as the soils and subsoils of lands first irrigated become thoroughly soaked with water and settled down; as the knowledge of preparations and manipulations necessary for econom-

ical use of the waters is spread amongst the irrigators, there will continually, from time to time, appear a surplus of water available for the irrigation of additional lands. Whenever this becomes apparent, existing districts may be extended, or new districts chartered.

As the matter stands now, irrigation can be expanded at once over a much greater area than it yet has covered, but in the quarters of the State where it is a necessity, the acreage can be brought up to a quantity near the area demanding water, only by increasing the water supply and preventing waste or unnecessary use of it.

(B)—As a preliminary measure the irrigation districts cannot be finally designated.

Although we may determine the natural boundaries of the irrigation districts of the plains, and complete the outlining of such divisions by artificial grade lines for canals, we cannot intelligently indicate the districts, or portions of districts, which can now be irrigated with the water available for the purpose until it is known how much land can be irrigated from each source of supply.

The reason for this is because the water supply is not great enough in most quarters to afford sufficient with which to bring all of the land demanding it under cultivation at once. For the consumption of water during the first years of irrigation is enormous, as compared to what is necessary to effect this irrigation in old settled districts.

(C)—In the preliminary formation of irrigation districts, the great natural districts of the country cannot always be closely adhered to.

It would be injudicious in the primary designation of districts which must act as units in the construction and management of irrigation works, to define and rigidly adhere to the great natural districts of the plains, for the reason that the water supply must necessarily be short for use over the full extent of these districts for some time to come; and, from attempting too much, irrigation would fail of success.

It cannot be told what extent of land may in the future be irrigated until a definite knowledge of the water supply is obtained, and until, by observation, it is learned how much land a given quantity of water will irrigate; and also until it is known that appropriators will not be allowed to waste the supply. And hence:

(D)—The final outlining of great irrigation districts must be a work of time.

The extension and definite outlining of the great irrigation districts, and their establishment in working order, as well as the primary designation of additional and final districts, and the construction of works for the watering thereof, should be accomplished according to a gradual process of development, both as the water supply will admit of more land being irrigated and as population becomes sufficiently numerous and skilled in the art of irrigation to place such enterprises upon firm business bases.

Sufficient reason for this conclusion have already been given under former headings. But it is at just this point where it should become perfectly apparent that the facts heretofore brought out must have a

bearing upon the policy to be pursued by the State towards irrigation, as the next conclusion is the logical consequence.

(E)—The cost of works of irrigation proper should be borne solely by the property directly benefited by their construction.

The State could not with safety enter upon the construction of irrigation canals, or materially encourage the building of such works, upon any other basis than that of the entire burden of the cost being borne by the property benefited, for the following reasons, viz.:

With such encouragement works of irrigation would inevitably be pushed beyond the capacity of the water supply to fill the demand, and beyond the ability of the people to use the diverted water profitably.

Thus, irrigation would fail of a fair measure of success from one or both of these two causes, and the State would have to make good towards the payments of debts incurred, what could not be derived from the projects in the legitimate manner.

But there is a saving clause which must not be overlooked here. The State owes a duty to this great interest, as will become apparent by what follows.

(F)—The water supply will do greater duty in the future than it has in the past.

The scarcity of water for irrigation, which has occurred in the past, in the principal irrigation regions of the State, has been more apparent than real. Its inadequacy for the watering of the acreage under cultivation, or preparation therefor, has been due in a measure to great loss from main and distributing works, and extraordinary consumption on the lands themselves, partly inseparable from the operations during the first years of use of canals and irrigation of lands; but it has also been due to loss or waste which, in many cases at least, could have been prevented. And hence it is most important that the State provide some system, not of works, but of laws and regulations under which the most shall be made of the supply, by which it will be known when and where and how much of a water supply is available for irrigation, and who has the right to use it; and whereby, also, waste or unnecessary use of water will be prevented.

(G)—Existing claims to water must be defined and adjusted.

In view of the fact that there are most indefinite, not to say extravagant claims, in many instances to the waters of the principal sources of supply, it is necessary that some more exact, not to say reasonable, limit should be set upon such claims, in order that it be known what balance of water, if any there may be, unclaimed for disposition in watering the yet unirrigated lands.

There should be no argument necessary to substantiate this conclusion; but lest I be misunderstood, I remark that such action need not be an interference with existing rights to the full extent of present appropriations or contemplated extensions; provided that due diligence is exercised in making good future right to the use of the supply; and further provided that the water is made to do a reasonably

large duty; in other words, is not wasted. The realizations of these conclusions means the establishment of system in irrigation. Hence the next paragraph is important.

(*H*)—*Great harm has been done to the best interests of California, by obstructing the development of her agricultural resources through a defective water right system.*

The acquirement of a privilege to appropriate water for purposes of irrigation, which is really not a right in any sense until the water is diverted and used (and then not an absolute one), is of no great practical value to the farmer without capital, or to a community of farmers without thorough organization, except that he or they be permitted to construct such cheap and flimsy works as for the time being will serve the demands.

Yet such has been the essence of the system in California, and the result is seen in the unfortunate condition of things heretofore mentioned, as the most important facts relative to the appropriation and use of water for irrigation; which state of facts abundantly proves that the water right system is defective, and its working has hindered the development of the agricultural resources of the State.

(*J*)—*The water right system of the past and present is resulting in the monopoly and waste of water.*

The appropriation law, framed with the intention, no doubt, of placing the water within the reach of all, leaving it open to public use, or putting it in the hands of local authorities to be given away on demand, without restriction or regulation, has resulted generally in benefiting those only who were able to profit by the advantages offered.

In the Report of the United States Board of Commissioners on the Irrigation of the San Joaquin, Tulare, and Sacramento Valleys of California, published in 1874, where we find the fundamental principles that should govern in the treatment of the irrigation question by State and governmental authority ably set forth and intelligently discussed, this axiomatic fact is stated:

> In seasons when there is a great surplus of water there can be no objection to a more liberal use of it, but it seems to us indispensable that the State should lay down a general rule. There ought to be an established allotment, which may vary in different districts. The cultivators who come first ought not to be allowed to appropriate more water than they require, because, if they do, those who come after will not be able to procure a fair supply.

If the ultimate result has not already been secured, it certainly will be in the future. Those who will have the right to use water will not share it on reasonable terms with those who have not that right; and unless there is State regulation of the distribution of the supply from the streams, and State restriction as to amount which may be used under the various circumstances, the water will not be brought to near its maximum duty, and the State will be the largest sufferer. For her Courts will be crowded with litigants over water claims, and a large area of land in the aggregate, which might support a thriving population and pay a large revenue, will remain dry and unproductive, while those which are watered will not have settled values. There can be no denying this tendency of affairs even now, and

the experience in all older countries should convince us that we have nothing better to expect, unless the right on the part of the State to supervise the distribution of water from the streams is asserted and acted upon at an early day, before matters have gone too far to be easily placed upon a sound basis.

(*K*)—*The working of a proper water right system will solve the problems of irrigation.*

The establishment of a proper water right system will do more to bring about a solution of the three great problems of irrigation heretofore mentioned (see Introduction, page 7), than all else which can be accomplished at this time. Such a system would have for its immediate object the prevention of waste of water from any cause, the adjusting of the extent of water privilege to the areas of land to be irrigated, and the granting of privileges to irrigate more land as the water supply is developed, according to such regulations as will insure the conservation of the waters. Thus, with proper administration, the first and second problems will be solved.

Solution of the third problem.

Any large body of fairly good land adapted to irrigation, within the valleys of California, to which is attached a good and sufficient water right, under a system which pledges the good faith of the State to see that it is respected, not dragged into Court for adjudication as to its legitimacy or priority over some other claim, is in itself a sufficient basis of credit upon which to obtain the capital for its development by irrigation when brought into proper organization. When this state of things obtains, then will the third problem be solved.

The solution of a fourth great problem.

Irrigators to be skilled in the highest degree, and enabled to profit most by the use of a minimum quantity of water, must be in a great measure permanent residents upon the lands which they work, and by experience in their own particular fields learn how to work them to advantage. Hired labor, and consequently all labor on large land holdings in California, can never attain to great skill in irrigation, because it is that of a transient population unused to the soil, the slopes, the appliances, and works of the fields in which it is called upon to manage the water.

We can only expect to have communities of real irrigators under a water right system, which protects the smallest cultivator in his rights to a fair portion of the water. Thus we can only hope to see the solution of the fourth great problem of irrigation, under the working of a water right law administered by the State.

PRESENT CONDITION OF IRRIGATION AFFAIRS.

A business like water right law needed.

From what has now been said it should be apparent that the first step towards the solution of the problems of irrigation must be the provisions o fsome more businesslike system, whereunder the distribution of the water from the stock on hand—the streams in their different stages—shall be accomplished according to the legitimate interests had therein, to be used in irrigation under regulations that will insure, as far as possible, against waste.

The water laws of other lands—Conservations of the waters.

Irrigation systems which have grown up in other lands, where the art has long been practiced, have constantly tended towards the accomplishment of the one grand object, which is herein spoken of as that towards which California must aim.

To the water laws of Italy, France, and Spain we might turn for suggestions. It cannot be said, however, that in either of these countries the conservation of the waters has been accomplished in as great a degree as could be desired. The statistics do not show that its duty is in all instances brought to nearly the point where it should be. But the reason is apparent; we may read it on every page of the chronicles of their experience, and we should profit by what has been so dearly bought by them.

Undefined water rights defeat all systemization.

Long ago, during the earlier years of systematic irrigation in the countries spoken of, customs of unlimited appropriation of water, and of extravagant grants of water rights, in turn prevailed. Under these were established privileges claimed by their possessors to be practically unbounded and above regulation. All of the waters of the streams were taken up; and for years, yes centuries, as time wore on, there has been a continual effort to bring these claims within bounds—to prevent waste, and insure a fair distribution among the claimants.

California establishing undefined water rights.

It is just this history which will be repeated in California, unless the present water right system is amended. We, in the latter part of the nineteenth century, have started in this matter where the Spaniards did during the reign of Ferdinand and Isabella, or even earlier, and where Italy was several centuries ago.

Existing rights need not be attacked.

And here let it be remarked, that, it is the perpetuation of an evil system (which is constantly laying a broader foundation for trouble, but is just now commencing to make itself manifest), against which it is intended this report shall speak. To prevent the extension of a harmful practice, and not to dispute existing rights, is the duty of the hour. Indeed, it may be said that thus far no such bad results have been developed, which cannot in great measure be remedied by a patient and just administration of a good water right law without injuriously affecting such interests.

Water appropriations of the past.

Those who have thus appropriated the waters of California's streams, have done so under her laws; and the laws are at fault primarily, and not the water appropriators. These persons should therefore have their rights respected. They found a law which said in effect: "You can have all you want on application for it; there is no administration of the stream and waters of the State; administer them yourselves." And they have taken advantage of the permission given.

The class of works constructed.

Some, being almost without means, have as best they could constructed canals, from which great waste of water is inevitable, and which can never give satisfaction to their owners or to the State.

Others, with lands and means at command, have built a better class of works, from which the losses are not so great, and which doubtless are capable of being made efficient parts of a good system. The above is the general rule, although there are exceptions.

Water monopoly does not always bring waste.

From this it will be noticed that the first effect of the evil system is apparent more from the works of the very class of people for whose benefit a more perfect system is most demanded, that is, the appropriators of least means.

FINAL CONCLUSIONS.

I conclude: That there is a necessity for State action in irrigation matters.

That the State should not construct irrigation works.

That she should foster irrigation interests by establishing a business basis for enterprise in irrigation projects.

That this basis is to be established by enacting a system of water laws under which water rights will be quieted, and capital will find safe investment in irrigation enterprise.

This subject is one for the most careful and profound treatment, and it cannot be dealt with at the present time in one comprehensive enactment. The following principles and points should, in my opinion, form the basis of treatment:

Primary principles and points.

(*a*) The control of the streams and the waters in them should rest with the State, and the distribution of the water supply to the works of irrigation or to the irrigation districts should be conducted according to State schedules and regulations.

(*b*) Rights or privileges to use water for irrigation should hereafter be attached to the lands to be irrigated, gauged to the quantities necessary to effect the irrigations, should be classified and graded.

(*c*) The distribution of water from the works to the lands should rest entirely with the irrigators, or those chosen by them, or by those in control of works; but all works should be maintained in a condition to prevent waste of water, and to this extent should be subject to State inspection and regulation.

(*d*) The cost of works of irrigation should be borne wholly by the lands to be irrigated in each instance.

(*e*) The system should admit of capital becoming interested through negotiations with irrigation districts.

(*f*) Existing water privileges generally should not be interfered with further than necessary to prevent the waste of water from badly constructed canals and insufficient preparation of lands to receive irrigation.

(*g*) In the definition of rights, irrigation should be declared a higher use of water, *when conducted by or under an organization directly and specifically recognized by the State as an irrigation district.*

(*h*) All water rights or privileges should be subject to condemnation, only for some higher use as recognized in each instance by the State.

(*i*) The rights of riparian owners should be recognized as preferred privileges to water for stock and domestic purposes.

(*j*) Sources of water supply for cities should be exempt from condemnation for irrigation purposes.

(*k*) The streams of the State should be classified, and those navigable, or directly tributary to others which are navigable, should be the objects of special State regulations, as to the quantity of water which may be abstracted during any season for irrigation.

RECOMMENDATIONS.

The foregoing is an imperfect outline of a great subject. I cannot recommend that any final action be attempted in the matter of water laws at once. It is necessary, however, that an exact knowledge be had of the field and of the present condition of water right interests before attempting to put any irrigation law in force.

Now, in view of the fact that the State Engineer has thus far been instructed to report upon the "principles which should govern in the irrigation of lands," and that this report is made in compliance with that instruction, and seeing that he is also instructed to "make such practical recommendations as he may see fit," I now recommend that this investigation be carried into a more practical and exact sphere of action, as follows:

First—That the State Engineer be authorized to ascertain and report the exact condition of all water right claims and works for the diversion of water from the streams and other sources of supply.

Second—That observations to ascertain the extent of the water supply, and the duty of water under different circumstances, be continued.

Third—That special examinations be made concerning the possibility and cost of saving the water supply by storage, and developing it by deep dams, as heretofore spoken of.

Fourth—That the State Engineer shall be instructed to report to the Governor, on or before the first day of October, 1880, a draught of a proposed code of irrigation laws. The same to be considered by the Executive and transmitted to the Legislature at its next session, with such recommendations as the Governor may see fit.

Respectfully submitted.

WM. HAM. HALL,
State Engineer.

APPENDICES TO PART IV.

[APPENDIX A.]

REPORT ON IRRIGATION WORKS AND PRACTICE

— IN —

LOS ANGELES AND SAN BERNARDINO COUNTIES

JAS. D. SCHUYLER, ASSISTANT ENGINEER.

CHAPTER I.

INTRODUCTORY;
TOPOGRAPHICAL FEATURES;
SOURCES OF WATER SUPPLY;
ARTESIAN WELLS.

OFFICE OF STATE ENGINEER,
SACRAMENTO, Cal., January 1st, 1880.

Wm. Ham. Hall, State Engineer:

SIR—In March last, while making an investigation on the subject of irrigation in Kern County, I received instructions from you to proceed to Los Angeles and San Bernardino Counties to make a general reconnoisance of the country, and familiarize myself with the works and practice of irrigation in that section, preparatory to the commencement of the surveys that might be necessary, and the more detailed study of the subject which was expected to follow. The time allotted was limited and barely sufficed to travel over the country and view, in a general way, the leading works. The field is an extensive one, the systems of irrigation various and complex, the sources of water supply numerous, and to add to my difficulties, no general maps were in existence showing the location of the ditches, while there was in many localities a perplexing confusion of names. After the first tour of inspection, the work to which I had been assigned in other parts of the State demanded attention, and there was left but sufficient time to make another trip more rapid than the first, in company with two assistants, for the purpose of measuring the discharge of the streams and ditches. Even in this latter work one important section, that of the lower San Gabriel, had to be omitted, and the gaugings that had been made by local engineers accepted in lieu of our own. The data upon which this report is based are, therefore,

necessarily incomplete, and gathered in too hurried a manner to serve other than to give a general idea of the extent of irrigation and the characteristic features of its practice.

Collection of statistics.

The collection of reliable statistics of this character is a work requiring much patience and the exercise of considerable judgment. The statements of men little accustomed to systematic observation, or unused to making record of their work and its results, differ so widely on the simplest subjects that they must need be verified by painstaking and extended inquiry. Many who were unfamiliar with the object and purpose of the work, appeared suspicious that by some means their rights were to be invaded, and were either entirely reticent or purposely gave incorrect statements in reply to inquiries. There is apparently no subject upon which men are more sensitive than that of their water privileges. Water seems to be an evanescent species of property which they are in constant fear of losing. I was fortunate in meeting many liberal-minded gentlemen, on the contrary, who gave me freely the results of their experience, and to whom I am indebted for the most reliable information contained in the following pages.

District maps.

Six maps of the different sections of the two counties where irrigation is practiced, drawn on a scale corresponding to that of similar maps of this Department, have been prepared by local draughtsmen, at considerable expense, to accompany this report. Upon them are represented for the first time the various irrigation ditches of the country, and the lands commanded by them.

TOPOGRAPHY AND GENERAL FEATURES OF COUNTRY.

Mountain ranges.

The leading topographical features of Los Angeles and San Bernardino Counties, unlike those of any other portion of the State, consist of two mountain ranges, running nearly parallel to the coast, the drainage from the higher range passing across an interior valley and breaking through the lower or coast range, finding an outlet across a second valley directly to the sea.

The Sierra Madre range.

The upper range is apparently a southern continuation of the Sierra Nevada of northern California. In Los Angeles County it is called the Sierra Madre, and in San Bernardino County, the San Bernardino and San Jacinto mountain range. Its highest peaks have an altitude but little short of the prominent peaks of northern California, and some are crowned with almost perpetual snow. Unlike the Sierra Nevada, however, this southern mountain range has no broad belt of rolling foothill lands between it and the adjacent valley, but breaks precipitously off to a smooth sloping plateau, one to five miles wide, which extends for a considerable distance along the base of the mountains through both counties. It has a slope from the mountains of 100 to 300 feet per mile. The geological formation of the mountains is indicated, to some extent, by the character of this plateau, which is evidently composed of the detritus washed down from

the steep mountain slopes. From the Los Angeles River east to the line separating the two counties, the soil of this plateau is, generally, composed of red loam, compact and deep, containing considerable clay and fine gravel; while farther east, through San Bernardino County, gray granitic sand, gravel, and bowlders are the leading soil characteristics. In Los Angeles County this plateau in many places breaks off with a nearly vertical bench, along the rim of which large springs burst forth; but, in general, it slopes directly to the interior valley, with no perceptible division separating it from the valley proper.

The interior valley.

The interior valley between the two mountain ranges extends, with but one intervening ridge, from San Fernando to San Bernardino, a distance of 80 or 90 miles, and has a general width of five to twenty miles.

The coast valley.

The coast valley slopes from the Coast Range to the sea, having a length parallel with the coast of about 40 miles, and a general width of 15 to 20 miles, although very irregular in shape and outline.

Location of irrigated lands.

These two valleys, with the smaller ones merging into them, and the plateau described, embrace nearly all the irrigated lands of Los Angeles and San Bernardino Counties. The special characteristics of topography and soil in particular localities will be hereafter referred to.

Drainage lines.

The higher interior mountain range is drained by three principal streams which break through the Coast Range with independent outlets to the sea; *i. e.* the Los Angeles, the San Gabriel, and the Santa Ana Rivers. These are fed by numerous tributaries which join them before reaching the Coast Range, but on their further course to the sea they receive no important accessions to their volume. During the rainy season these streams and their tributaries are dangerous torrents, sweeping down from the mountains in which they rise, in large volume and with great velocity, carrying a mass of bowlders and gravel far out into the valley. They subside as quickly as they rise, and during the summer would dwindle to nothing, but that their supply is maintained by springs which appear in their beds from hidden sources.

The Santa Ana River.

The largest of these streams is the Santa Ana River, which drains a watershed of about 1,210 square miles, or 2,600 square miles if we include the San Jacinto River drainage system and that portion of the interior valley and plateau in San Bernardino County, covering over 600 square miles. The San Jacinto River, whose principal tributaries rise in San Diego County, discharges into Lake Temecula, whence the waters seek an outlet to the Santa Ana River, 30 miles north, via Temescal Creek. The river has not a constant flow into the lake, but reaches it only for a few weeks each year, in June or July, during the season when snows melt most rapidly. The overflow

channel of the lake is some 20 feet above the low water level of May last, and except in years of extraordinary floods like those of 1862 or 1868, the lake receives no more than is sufficient to maintain the loss by evaporation. It has a length of three to five miles, a width of one to two miles, and a maximum depth of 250 feet. It lies at an elevation of about 1,300 feet above sea level.

The San Gabriel River.

The San Gabriel River is second in size of the three, and drains a watershed of about 356 square miles of mountain and 181 miles of interior valley.

The Los Angeles River.

Los Angeles River has a total drainage area of about 320 square miles of mountain and 182 miles of interior valley.

WATER SUPPLY.

The water used for irrigating in Los Angeles and San Bernardino Counties is derived from various sources, as follows:

First—Natural streams.
Second—Springs.
Third—Artesian wells.

Supply from natural streams.

The first of these sources of supply comes from the mountains—almost wholly from the higher interior range—and the volume of water thus available is subject to great variation. I have no data for determining even approximately the maximum or minimum discharge of either of the three principal rivers. Gaugings were made of them and of their tributaries in May last, but these do not represent even the minimum discharge, as they were considerably diminished in volume at a later period. They afford, however, a basis of comparison as to the relative value of each at a given time, and a general idea of their flow at an important period of the irrigating season.

Districts supplied by the three principal rivers.

The lands irrigated from the three principal rivers are naturally divided into five irrigation districts.

The Los Angeles District comprises all the lands irrigated from Los Angeles River, confined chiefly to the limits of the City of Los Angeles.

The upper San Gabriel District includes all the lands irrigated from the San Gabriel River between the Sierra Madre and the Coast Range.

The lower San Gabriel District embraces the irrigated lands lying between the Coast Range and the sea.

These three districts are all in Los Angeles County.

The lands irrigated from the Santa Ana River form the other two districts, namely:

The upper Santa Ana District, lying wholly in the County of San Bernardino, between the San Bernardino Mountains and the Coast Range; and the lower Santa Ana District, lying between the Coast Range and the sea, in Los Angeles County. The upper of these two districts may be again subdivided into two distinct districts, one of which includes the lands irrigated from the waters that emerge from

the mouth of the Santa Ana cañon, where the entire volume of the summer flow is diverted; the other, the lands lying below the point where the Santa Ana River receives a fresh supply from the drainage of the springs, artesian wells, and streams of the San Bernardino basin.

A description of the leading characteristics of each of these sources of supply is now necessary to a correct understanding of the varied conditions peculiar to them.

Los Angeles River characteristics.

The drainage of the Los Angeles River, after leaving the Sierra Madre Mountains, is received into the large basin of the San Fernando Valley, whose soil is gravelly and porous, but probably underlaid with an impervious substratum of clay or rock, and, acting as a great sponge, it holds the water it receives and gives it off slowly. This valley is shut in on the south by the Coast Range, at the foot of which the river runs, finding an outlet through the hills by a narrow gap just above the City of Los Angeles. The streams emptying into this basin are the Paloma, the Pacaima, the Tujunga and the Verdugo, of which the largest is the Tujunga. Like all the mountain torrents which descend from the Sierra Madre, they have a very rapid fall, and on reaching the valley spread out into broad "washes," whose beds are composed of bowlders, gravel, and coarse sand. In flood they flow entirely across the valley to the Los Angeles River; but in summer the water barely emerges from the mountains and sinks from sight in the porous channels. The Arroyo Seco, another large tributary having the same characteristics as the other mountain torrents, enters the river at the City of Los Angeles. In May last the discharge of the river at the mouth of Tujunga wash, ten miles above the city, where the upper dam of the Los Angeles irrigation system is located, was 24½ cubic feet per second. This amount was augmented by about 54 cubic feet per second from springs rising in the bed of the river at various points between this dam and the city. The total available supply, therefore, was about 78½ cubic feet per second—an amount which is but little diminished during the summer months. Below the city the river bed is broad, shallow, and sandy, and only upon rare occasions does the water ever find its way entirely through to the sea, but is absorbed by the thirsty sands.

Character of San Gabriel River.

The discharge of San Gabriel River at the mouth of the cañon is much more variable than the normal flow of Los Angeles River. In May, 1879, the total volume discharging at that point was but 35½ cubic feet per second, and later in the season the river was entirely dry, as I was informed. Ordinarily the flow is much greater in May than it was last season, which was one of unusual scarcity. Except in flood, however, it is seldom more than sufficient to fill the two irrigating ditches of the upper district, which head directly at the mouth of the cañon, and divert all the available supply, leaving the broad rocky bed of the stream entirely dry for ten or twelve miles, when the water begins to reappear in the channel a short distance below the bridge of the Southern Pacific Railroad, and but a little way above the broad gap through the Coast Range. At this point the river has two distinct and diverging channels, one to five miles apart, having independent outlets to the sea. In each of these channels there are numerous springs, the water rising at a number of points along their course, forced to the surface by the impervious sub-

stratum of clay, underlying the whole lower valley at a depth of a few feet. From these springs is derived the supply for the elaborate system of irrigating ditches in the lower San Gabriel District. A plausable explanation of the existence of these springs may be found in the fact that the bed of the stream, before emerging from the mountains, is filled to an unknown depth with large bowlders, in which a large portion of the water sinks. The water flows beneath the surface until reaching the Coast Range, when the proximity of the impermeable strata to the top of the ground forces it to reappear. This fact will apply to all the mountain torrents rising in the Sierra Madre, and until controverted by a more reasonable theory the one advanced appears to me to sufficiently account for all the springs and artesian streams with which that country is so singularly favored. While on this subject I cannot refrain from mentioning the pet theory, seriously maintained by many people of Los Angeles, that their water supply comes from far distant sources, under and through the Sierra Madre. They point at the great lakes and sinks of rivers which have no apparent outlet, in Nevada and Utah, and believe these disappearing waters find an outlet to the Pacific through Los Angeles County. The people of Lombardy might as reasonably advance the theory that their *fontanili*, which supply such an enormous volume of water for irrigation, were derived from sources on the north side of the Alps.

Description of Santa Ana River.

The Santa Ana River resembles the San Gabriel, just described, in emerging from the mountains through a wild, rocky, precipitous cañon, over a bed of loose bowlders, in which the greater portion of its volume is lost before reaching the valley. The total fall of the river for 21½ miles above the mouth of the cañon is 4,100 feet, or over 195 feet per mile. The elevation above sea level at the mouth of the cañon is about 2,500 feet. In May last the discharge at the mouth of the cañon was but 28.7 cubic feet per second, all of which was diverted into two irrigation ditches. A few miles lower down water begins to rise, until at the head of the Camp Carlton Ditch, 10 miles from the cañon, we found a stream amounting to five cubic feet per second. This was all diverted by the ditch referred to, leaving a dry bed for 4 miles to the mouth of Warm Creek, where the river received a fresh supply of 75 cubic feet per second, from the drainage of the *cienegas* of the San Bernardino basin. From this point to the Bedrock Cañon, where the river passes through the Coast Range, the bottom lands are saturated with a succession of cienegas which, draining into the river, constantly augment the volume of discharge. The largest of these springs are those of Spring Brook, opposite Riverside, and those which form the supply of Rincon Creek, which is properly but a prolongation of San Antonio Creek.

Tributaries of the Santa Ana.

The principal tributaries of the river rising in the mountains and entering the stream in the San Bernardino basin above the Town of Riverside, are Lytle Creek, Devil's Cañon, Twin Creeks, City Creek, and Plunge Creek on the north, and Mill Creek and San Timoteo Creek on the east and south. Nearly all these streams have channels reaching to the river, but except in flood time their beds are dry below their point of exit from the mountains. Warm Creek, which is never dry, and is less affected by the seasons than the other streams, derives its

supply directly from springs or cienegas, is but four miles long, and has no visible connection with the mountains. Two other tributaries enter the river from the north, San Antonio Creek and Cucamonga Creek. They cross the high plateau west of the San Bernardino basin, with broad, gravelly channels; but they seldom carry sufficient volume of water to reach the river, except by the underground channels supplying the cienegas referred to. Nearly opposite the mouth of Rincon, or San Antonio Creek, another tributary channel, Temescal Creek, enters the river from the south, draining the eastern slope of the Coast Range, and as heretofore stated serving as the overflow outlet for the Laguna Temecula, and, indirectly, the San Jacinto River.

Between the various tributaries named there are a number of short cañons emerging from the mountains carrying small streams of water, all of which are utilized for irrigation. The only considerable tributary below Bedrock Cañon is Santiago Creek, which enters from the southeast, draining some of the highest mountains of the Coast Range and furnishing a small supply of water for irrigation.

The bed of the Santa Ana River is generally composed of shifting quicksands, constantly moving down stream. From the cañon it has a slope of over 100 feet per mile for several miles, over which section its bed is of bowlders. Below that point its slope is 15 to 20 feet per mile, to Bedrock Cañon, increasing in the cañon to about 30 feet per mile, and on reaching the lower valley diminishing to 12 to 15 feet per mile.

DISCHARGE OF STREAMS.

Having described the three principal streams affording water for irrigation, and given a general outline of their various tributaries, I now present the following summary, showing their discharge at the time of my visit in May last. There were no continuous observations through the season, as in the case of Kern River and other streams in the San Joaquin Valley, so that it was impossible to compute for any of these streams tables of daily and monthly discharges. The following streams are those only from which water is used for irrigation, and are mentioned in the order of their geographical position, commencing at the west and going eastward:

Watershed of Los Angeles River.

Los Angeles River	78.5	cubic feet per second.
Verdugo Cañon	1.4	cubic feet per second.
Arroyo Seco	5.0	cubic feet per second.
Total	84.9	cubic feet per second.
Total area irrigated by streams from Los Angeles River watershed	9,435	acres.

Watershed of San Gabriel River.

Precipico Cañon, Davis Cañon, Bailey Cañon, Little Santa Anita, Main Santa Anita, Sawpit Cañon, and Fish Cañon, in the aggregate, about	3.9	cubic feet per second.
San Gabriel River, at mouth of cañon	35.4	cubic feet per second.
San Gabriel River, below Coast Range, total of various springs	140.0	cubic feet per second.
Dalton Cañon, San Dimas Cañon, and Puente Creek, in aggregate about	12.5	cubic feet per second.
Total	191.8	cubic feet per second.
Total area irrigated by streams from San Gabriel River watershed	24,833	acres.

Watershed of Santa Ana River.

San Antonio Creek	12.4	cubic feet per second.
Cucamonga Creek	6.0	cubic feet per second.
Clark's, Reids, Smith's, Day's, and Sainsevain's Cañons, in aggregate about	4.9	cubic feet per second.
Lytle Creek	11.3	cubic feet per second.
Cajon Pass Creek, Devil's Cañon, Twin Creeks, City Creek, and Plunge Creek, in aggregate about	6.0	cubic feet per second.
Santa Ana River, at mouth of cañon	28.7	cubic feet per second.
Santa Ana River, total supply below cañon	117.3	cubic feet per second.
Mill Creek	5.7	cubic feet per second.
Ucuipa and San Timoteo Creeks, in aggregate about	4.0	cubic feet per second.
Temescal Creek, about	5.0	cubic feet per second.
Santiago Creek, about	2.2	cubic feet per second.
Total	203.5	cubic feet per second.
Total area irrigated by streams from Santa Ana River water shed	23,200	acres.

Trabuco and San Juan Cañons.

Flow not gauged, but roughly estimated at	8	cubic feet per second.
Total area irrigated by streams	400	acres.

Recapituiation.

Streams in Watershed of —	Discharge—Cubic feet per second.	Acres Irrigated, 1879.
Los Angeles River	93.5	9,435
San Gabriel River	191.8	24,833
Santa Ana River	203.5	23,200
Trabuco and San Juan Creeks	8.0	400
Totals	496.8	57,868

Remarks on discharge of streams.

It is to be regretted that our information on the average yearly discharge of the streams is so slight. There is abundant evidence of the fact that the principal rivers each carry 1,000 to 1,500 cubic feet per second for a few days at their highest stages, while in summer many of the tributaries cease flowing entirely. In March last the Santa Ana River, at Bedrock Cañon, in the Coast Range, at the heads of the Los Angeles County ditches derived from that stream, was carrying 200@300 cubic feet per second. In May the discharge had diminished to 58 cubic feet, and in August to 31 cubic feet per second. The river was never known to carry so little water at that point. The discharge as stated in March last, was said to have been much less than for many years at that time of year. There is a general belief that the stream has been gradually failing since the settlement of the country, and some facts are brought forward which appear to support that idea. The cause is attributed to the destruction of forests in the mountains, which has been going on through the agency of the ax and the ravages of fires, for many years past. The San Gabriel River failed entirely in the month of September, at the mouth of the Cañon, and the drying up of several other streams in the past summer and fall is reported. The flow of the Los Angeles River is reported to have been but little diminished during the summer season.

IRRIGATION SUPPLY FROM SPRINGS.

The supply furnished by springs is much more constant and reliable than that of the natural surface streams, and at the time when irrigation is most needed, is probably greater than that from any other source, if we consider the remarkable manner in which the streams are reinforced by springs emptying into them.

Cienegas of San Gabriel Valley.

The series of springs or cienegas* which appear along the rim of the plateau, between Arroyo Seco and San Gabriel River, furnishing water for the irrigation of the far-famed orange groves and vineyards of the "San Gabriel fruit belt," is one of the most remarkable features of the country. There are no less than 18 distinct cienegas in a distance of eight miles, each covering from one to forty acres of ground, and supplying water for irrigating from 20@400 acres each. The total area of land irrigated by them in 1879 was about 3,100 acres, consuming but a portion of the water which is actually available. It is impossible to estimate the total water supply which the chain of cienegas is capable of producing, but the amount at present developed is probably not less than 25@30 cubic feet per second, which can be largely increased by methods to be referred to further on.

Cienegas in the City of Los Angeles.

In the center of the City of Los Angeles, on each side of the river, on the lower bottoms, are cienegas which afford considerable water, the supply apparently coming in from other sources than the percolation from the stream. One of these yields the entire domestic supply for the hilly portion of the city, on the west, the water being pumped to reservoirs 175 to 240 feet above the level of the cienegas, at a cost of 10 cents per 1,000 gallons.

Cienegas supplying Ballona Creek.

West of the City of Los Angeles, at the foot of low hills next the sea coast, there are large cienegas, covering several hundred acres, from which issues Ballona Creek, carrying, in May last, 8.6 cubic feet per second, and irrigating about 500 acres of land. This creek discharges directly into the sea, a few miles south of Santa Monica, and was probably at one time the main channel of the Los Angeles River. The flow of the stream is said to be but little affected by drouth, but is considerably increased during and immediately after the rainy season. In very dry seasons, when cattle go into the cienega to feed upon the marsh growth, the flow of water is said to be increased, the trampling of their feet apparently squeezing out the water as one would wring a saturated sponge.

Cienegas of Pomona.

Near Pomona there is quite a large cienega, which supplies water for 440 acres, the amount irrigated the past season. The total volume of supply is about three cubic feet per second.

* The word *cienega* is a Spanish term locally applied to the swampy or boggy ground caused by the rising of subterranean waters to the surface. A cienega always implies a spring and the marsh surrounding it, and as it is the term generally—I may say, exclusively—used in the section of country I am describing, it is best to adopt it.

San Bernardino cienegas.

The cienegas of San Bernardino basin are the largest of any in the southern country, and furnish the greater portion of the summer supply of the Santa Ana River. The two principal ones are near the Town of San Bernardino, and cover an area of over 300 acres each. They are said to be of comparatively recent origin. The older settlers can remember when the land which they occupy was comparatively dry. I was told that the volume of the stream issuing from them (known as Warm Creek, from the tepid temperature of its waters) has been slowly increasing in the past few years—doubtless from the drainage of the large number of artesian wells that have been bored in the neighborhood, and from the drain ditches that have been cut through and into the cienegas. At the time of my visit, Warm Creek was a beautifully clear stream, carrying over 80 cubic feet per second, and furnishing water power for two flouring mills. There are spots in the Valley of San Bernardino where, after very wet seasons, springs burst forth, forming cienegas, which dry up again, after a few years, until another season of extreme rainfall.

Opposite the settlement of Riverside, in the bottom lands of the River Santa Ana, are other large cienegas adding 25 to 30 cubic feet per second to the volume of the stream, and below them, as I have before stated, the river receives constant accessions from similar sources in the 18 miles of its course from Riverside to Bedrock Cañon. As these cienegas which discharge directly into the river have been included in the estimate of the water supply and the lands irrigated from natural streams, the volume of water taken from them for irrition, before reaching the drainage channels, is smaller, and the area thus irrigated does not properly represent the total area irrigated by springs. The streams and springs are so inseparable that it is impossible to estimate the duty done by each. There are, however, about 1,800 acres irrigated almost directly from cienegas in the San Bernardino Valley, and the volume of water thus used may be approximately estimated at about 20 cubic feet per second.

Cienegas of the coast valley.

In the great coast valley of Los Angeles there are many large cienegas which, aside from those supplying Ballona Creek and the San Gabriel River, are not used for irrigation.

Recapitulation.

To recapitulate, the cienega irrigation may be grouped as follows:

Cienegas of Los Angeles River Valley, supplied by drainage of Los Angeles River watershed	1,150 acres.
Cienegas of San Gabriel watershed	3,697 acres.
Cienegas of Santa Ana River watershed	1,775 acres.
Total	6,622 acres.

Total apparent water supply, 50 @ 60 cubic feet per second.

Total area irrigated.

The total area of land irrigated from the principal natural streams and cienegas in the two counties—Los Angeles and San Bernardino—is, therefore, as nearly as may be estimated, 64,490 acres, and the total water supply in May, 1879, about 550 cubic feet per second.

IRRIGATION SUPPLY FROM ARTESIAN WELLS.

The third great source of water supply for irrigation is derived from artesian wells. The area of land dependent upon flowing wells for its sole supply of water is a large one, and, although in some parts the limits of the artesian belts have been quite closely defined by experiment, it is undoubtedly true that this source of water supply is not thoroughly explored, nor the extent of the supply thus available fully developed or known.

The great coast valley artesian belt.

The greatest artesian belt in all southern California is that running through the Coast valley of Los Angeles, having a length of 40 miles, and a width, as at present explored, of 2 to 12 miles, the total area being about 300 square miles. The Rivers Los Angeles, San Gabriel, and Santa Ana cross the belt on their way to the sea, and the fact that the wells having the strongest flow are adjacent to the channels of these streams seems to indicate that the water supplying the wells is that which has disappeared from the streams above and percolated between impervious substrata at an elevation sufficient to give the head or pressure by which it is forced again to the surface through the outlets furnished by the perforations.

The wells of this belt are in three general clusters—those in the vicinity of Compton, adjacent to the River Los Angeles; those in neighborhood of Artesia, near the San Gabriel, and those in the settlement of Westminster, near the channel of the Santa Ana River. Between these settlements, and in all directions from them, there are a number of wells which indicate the limits of the belt, but the majority of them are in the vicinity of the settlements named.

Number of wells.

The number of wells in the belt is estimated at about 550, and new ones are being constantly added.

Discharge of wells.

The flow from them is, of course, extremely variable, depending upon their location, the size of the pipe, the number and size of the perforations or slits in the pipe through which water is admitted, the character of the water-bearing strata at which the perforations are made, and to some extent upon the season. The greatest discharge from any one well is about 1.7 cubic feet per second—the quantity flowing from the locally famous Burlingame Well near Compton. A common discharge is 0.2 to 0.3 cubic feet per second.

Depth of wells.

Their depth is from 50 to 550 feet, the general depth being from 150 to 200 feet.

Duty of wells.

Some of the wells irrigate 100 to 200 acres each. A well which will irrigate 40 acres is, however, considered a very good one.

Discharge and duty of wells in the coast valley.

For the purpose of an approximate estimate of the duty performed by artesian water in Los Angeles County, I have taken as an average

30 acres irrigated by each well, giving a total of 16,500 acres irrigated in this belt by artesian water alone. The average discharge of the wells probably does not exceed 0.1 cubic feet per second, or a total of say 55 cubic feet per second from all in the belt. There are several other localities of small area in Los Angeles County, outside of the main artesian basin, where flowing wells have been obtained, the total number of wells not exceeding ten.

Artesian explorations—Characteristics of wells.

As there is no locality in California where explorations for artesian water have been so extensively conducted, and with such remarkable success, as in the Counties of Los Angeles and San Bernardino, where the flowing wells number in the aggregate from 950 to 1,000, I have considered that a general account of the experience acquired on the subject in that section, so far as I was able to glean information respecting it, would be of sufficient interest to apologize for the space it will occupy in this report.

The first flowing well obtained in Los Angeles County was bored by ex-Governor Downey, 2½ miles west of the Village of Compton, in 1868. The success attending this experiment incited others in the neighborhood to test the possibility of tapping the same subterranean stream, to reap the benefit and secure the luxury of a perennial fountain of crystal water. Since that time the progress has been constant and rapid, until now almost every farmhouse within the limits of the belt has its spouting well. The pipes are usually carried two or three feet above the surface of the ground, and the water pouring over the top has the appearance of a dome of glass, resting on the earth, and forming a most refreshing sight upon the dry plains as it glitters in the sunlight.

It was found in boring the first wells that the upper water-bearing stratum, 40 to 125 feet below the surface, was composed so largely of fine quicksand that to end the pipes in this stratum endangered their success, as the sand quickly filled the wells and shut off the egress of the water. It was consequently necessary to go deeper to a second stratum, shutting out the sand encountered in the first by forcing the pipe further down. The second stratum in many cases, although affording a good stream of water, was open to the same obstruction from sand, and a third was sought. The latter was usually composed of gravel, but contained sufficient sand to be bothersome.

Perforation of pipes.

To overcome these obstacles and at the same time to utilize the several water-bearing strata that had been passed by the pipe, a contrivance for perforating the casing was invented. This consisted of a knife so arranged as to cut a thin slit in the pipe, opposite the water-bearing strata (a record of the depth and thickness of which had been carefully preserved), about six inches long, and so narrow as to exclude the sand and admit the water. This practice is now universal, and has largely increased the supply. The slits are made about six inches apart, longitudinally parallel with the pipe, and in groups of not more than three in any one section. If the water-bearing stratum is 20, 30, or 40 feet in thickness, the pipe is perforated throughout the whole distance, the bottom of the pipe always resting on an impervious stratum. Great care must be taken not to make

the slits too wide, as they are always liable to be the means of filling the pipe with sand and shutting off the flow.

One well, eight miles south of the City of Los Angeles, is 333 feet deep. The first artesian water-bearing stratum was struck at 85 feet, and was 10 feet thick. The second occurred at a depth of 316 feet, and extended as far as the pipe could be pushed down—17 feet—ending in coarse gravel. The force of the outpouring water from the last stratum was so great as to throw out a bushel of gravel stones, the largest just filling the pipe, and weighing four pounds. The head was sufficient to raise the water in a pipe 20 feet above the surface, although at two feet from the surface flowing but two and one-half inches over the top.

Southeast of New San Gabriel River, on the Alamitos Rancho, a well was sunk upon the summit of a mound, near the sea coast, 52 feet above the general level of the plain, in which surface water was found at a depth of 26 feet; and at 196 feet artesian water was struck, which rose within six feet of the surface.

Remarkable natural artesian spring.

One of the most remarkable natural artesian springs is found upon a high hill on the Cerritos Rancho, between Old and New San Gabriel Rivers. In a sag in the hill, some 60 or 80 feet above the surrounding plain, is a cienega from which water flows westward toward the sea and eastward toward the valley. In the southern portion of the artesian belt, in the vicinity of Westminster, two distinct water-bearing strata are found at depths of 80 to 230 feet, the lower stratum yielding the strongest flow.

The shallowest flowing well in the county is 1½ miles west of Santa Ana, a few hundred yards from the river channel. It is but 44 feet deep, and yields a large discharge. Three hundred yards away a well bored to a depth of 300 feet failed to get water.

Effect of increasing the number of wells.

It is found that as the number of wells increase, the flow of all is diminished, showing that the supply is comparatively limited. Some of the wells on the higher land have gone dry, or ceased to flow. Others flow only in spring time, when the water supply has been replenished by winter rains. Another natural effect has been noticed in some parts, that since the boring of so many wells, the level of the surface water in the adjacent country above has gradually lowered (as much as six feet at Anaheim within the past ten years), slightly affecting thereby the quantity of water required for irrigation on the lands thus sub-drained. Some of the cienegas on higher levels have also diminished in their flow.

Fluctuations in head.

The head or extreme height to which water will rise in the pipes, has, in Los Angeles County, as I was informed, steadily diminished in the past seven years, up to two years ago, when it had fallen six feet. Since that time, in the past two years the head has been slowly returning, about one and one-half feet having been restored in the neighborhood of Compton.

Wells in other localities.

Outside of the great coast valley artesian belt, flowing wells have

been obtained in other localities, of which brief mention is sufficient. Two wells recently bored on the San Rafael Rancho, north of Los Angeles, passed through four distinct water-bearing strata. One well was but 95 feet deep, the other 170 feet. They have a flow of one and one-half to two inches over the top of the pipe.

On the Santa Anita Rancho, in the upper San Gabriel Valley, there are two wells, 72 and 336 feet deep, respectively. On the adjoining property is a flowing well 200 feet deep. These are but a short distance from the base of the Sierra Madre.

Near Pomona there are four wells on a tract of 100 acres belonging to Captain Arthur Hutchinson, having an aggregate discharge of 1.3 cubic feet per second. Three are 160 feet deep, and the fourth was bored for experiment to a depth of 340 feet. Various attempts have been made to obtain artesian water in the immediate vicinity, but without success.

Temperature of artesian water.

The temperature of the Pomona wells, just mentioned, is 67° winter and summer alike, while the temperature of the other wells in Los Angeles County, as well as those in San Bernardino County, as far as observed, is but 62° Fahrenheit.

A singular fact in connection with the Pomona wells is, that by capping or uncapping any one of them the flow of the others is increased or diminished with regular pulsation.

The diameter of the majority of the Los Angeles County wells is seven inches, and the value of each is determined by the number of inches in depth of the flow over the top of the pipe two feet above the surface of the ground. A flow of one and one-half inches will discharge about one-fourth cubic foot per second, which is considered a very good well. In measuring the discharge of a few wells I found that the formula $Q = \sqrt{H^3}\ l\ 3.33$ gave results closely approximating the quantity obtained by actual measurement in a vessel, where Q = discharge in cubic feet per second; H = the depth of water in the center of the column above the rim of the pipe, in feet, and l = the total periphery of the pipe, in feet.

Cost of artesian water.

If we assume that the average cost of the artesian wells in Los Angeles County has been $400, and that the total number is 550, with an aggregate discharge of 55 cubic feet per second, the total cost foots up $220,000, or an average of $4,000 per cubic foot per second. When we consider the many failures that have been experienced in seeking for water, it will be seen that the luxury is a somewhat expensive one.

THE ARTESIAN BASIN OF SAN BERNARDINO.

In San Bernardino County the area in which flowing wells are obtained is confined to about 30 square miles, as at present defined, within which are the large cienegas and sources of Warm Creek. For the following description of the artesian basin, prepared at my request, I am indebted to F. T. Perris, civil engineer, of San Bernardino. He says:

"The Valley of San Bernardino has peculiar topographical features, a study of which makes apparent the fact that it was once a lake of

considerable proportions. On the north is the San Bernardino range of mountains, having an altitude of from 5,000 to 7,000 feet; on the east a low range of clay hills, having for their summit the divide of the San Gorgonio Pass; on the south a low range of clay and granite hills; and on the west a high mesa, forming the west bank of Lytle Creek.

"The natural gate, outlet, or drainage of the valley is in its southernmost portion, where the Santa Ana River passes between two hills of limestone, or rather what was once apparently one hill, since cut through. At this point the 'bedrock' is near the surface, forming the Valley of San Bernardino into a complete and large catchment basin for the watershed of a very large area of country, the main channel of drainage being the Santa Ana River.

"The soil of the valley, as far as pierced by artesian borings, shows it to be mainly granitic in character, stratified by alternating layers of clay, evidently swept in from the country east and south. Borings to a depth of 150 and 200 feet frequently pierce a bed of vegetable mold, proving that the valley has been filled up by gradual erosion of the surrounding hills. This being true, it may be readily believed that the Valley of San Bernardino, following a contour line from the level of the bedrock at the outlet before alluded to, is a lake of water percolating the coarse sands and gravel which underlie it, and from which the artesian supply is invariably derived.

"There are, unquestionably, artesian channels of water passing under ground from the mountains to the main drainage channel of the Santa Ana, and conforming in general characteristics to the surface channels. These, composed of sand and gravel, probably underlie clay and pass over cemented sand and gravel at a certain elevation around the margin of the valley, and furnish the 'head' to our wells. This theory is borne out by the facts presented in *digging* wells in certain localities. These artesian channels are believed to be as numerous as the surface streams which debouch into the valley, and all have an apex or point of concentration at the southwest corner of the valley, where our strongest wells exist, and cienegas and springs most abound.

"Those best informed estimate the number at 400 to 425—in diameter from two to eight inches, the greater number being but two inches in diameter. A list of 56 wells bored by one firm, the Benson Bros., shows the shallowest wells to be 80 feet, and the deepest 380, the average being about 160 feet.

"The most northerly well of the valley is 262 feet in depth.

"The most southerly well is 99 feet deep, and is the finest flowing stream in the valley. The most easterly well but one is 285 feet in depth. The deepest and most easterly well in the valley is that of Judge Willis of Old San Bernardino. This has a depth of 410 feet, and a diameter of seven inches. Vegetable matter, consisting of decayed tule roots and pine wood, was brought up from the last sixty feet. Small fish (suckers) two to four inches in length, resembling those found in the mountain streams, were occasionally ejected from this well. The well afforded a fine flowing stream but was afterwards spoiled through the effort of the well-borer to perforate the pipe at 350 feet and secure the first stream. The incisions were made too close together, a strip of the pipe was accidentally torn out letting in the quicksand so rapidly that all efforts to pump it out were futile.

It has now filled with sand and clay up to the height of the incision, shutting off the flow.

"Artesian wells are bored rather for domestic use and small garden irrigation than for general agricultural purposes. The two-inch wells therefore prevail on account of their economy in cost. The larger sizes do not afford a discharge commensurate with their greatly increased cost. This fact has seemed somewhat puzzling. I think it is due, however, to lack of head, as the increase in the weight of the column of water in the pipe retards the flow. This has given rise to the belief that a two-inch well affords as much water as one of three or four inches in diameter."

Discharge of San Bernardino Wells.

The aggregate discharge of the wells of San Bernardino, the majority of which are but two inches in diameter and afford but little water, probably does not exceed 15 to 20 cubic feet per second.

The total artesian water supply of the two counties may therefore be approximately estimated at about 70@75 cubic feet per second.

Summary of water supply.

Summing up the entire visible water supply in May, 1879, the following approximate figures are shown:

Supply from natural streams	495	cubic feet per second.
Supply from cienegas, say	55	cubic feet per second.
Supply from artesian wells, say	75	cubic feet per second.
Total	625	cubic feet per second.

Summary of area irrigated.

Irrigated from natural streams	57,853	acres.
Irrigated from cienegas	6,622	acres.
Irrigated from artesian wells	18,000	acres.
Total	82,485	acres.

Remarks on water supply.

I am inclined to think the aggregate water supply shown in the foregoing estimate represents a fair yearly average. Earlier in the season the supply was much greater, and in the Fall it was much less. Some of it was doubtless twice measured, as the drainage of cienegas and irrigated lands partially returns to the streams at lower levels, and the streams in turn sink and reappear to supply other cienegas and artesian wells. An average discharge of 625 cubic feet per second through the year would be equivalent to but three inches drained off from the total watershed area of the streams.

TABLE SHOWING RELATION BETWEEN RAINFALL AND DISCHARGE OF STREAMS.

The following table shows the average quantity in cubic feet per second that would be drained off the watersheds of the several streams in one year, with different depths of rainfall, allowing 50 per cent. for loss by evaporation and for the support of natural plant growth:

Name of Watershed.	Area of watershed in square miles. Mountain portion	Upper valley portion, above coast range	Average discharge per second, with rainfall of 12 inches, over whole watershed area	Average discharge per second, with rainfall of 24 inches over whole watershed area	Average discharge per second, with rainfall of 6 inches on valley portion and 12 inches on mountain portion of the watershed area	Average discharge per second, with rainfall of 12 inches on valley portion, and 24 inches on mountain portion
Los Angeles River	320	182	221.9	443.8	181.6	363.3
San Gabriel River	356	181	237.3	474.7	197.3	394.7
Santa Ana River	1,287	607	837.1	1674.3	702.9	1,405.9
	1,963	970	1296.3	2582.8	1,081.8	2,163.9

Illustration of table.

With an average rainfall of but six inches, over its whole watershed area, the Santa Ana River, for example, allowing 50 per cent. for loss, might discharge 1,000 cubic feet per second for three months of the year, and over 200 cubic feet per second during the remaining nine months. This amount of rainfall is common to the valley, while in the mountains it is known to be generally largely in excess, although no definite statistics are in existence.

I have elaborated the discussion of the water supply of Los Angeles and San Bernardino Counties, to show how bountifully the country has been provided for, and the many ways nature has arranged for its distribution and conservation.

METHODS OF INCREASING THE AVAILABLE SUPPLY.

Various means have been adopted and are being brought into use for increasing the volume of supply by forcing to the surface the waters that hide in the earth and seek outlets by subterranean passages to the sea. For the three main rivers, submerged dams of concrete, founded on impermeable strata, at the point where they pass the coast range of hills, have been proposed, but, as yet, have not been attempted. The city authorities of Los Angeles caused a series of borings to be made in the channel of the River Los Angeles, at the head of Zanja Madre, which showed alternating strata of clay, sand, and gravel, one to ten feet in thickness, and very irregular in profile, with sandstone bedrock at a maximum depth of 27 feet. The cost of a dam extending sufficiently far across the valley to confine all the water and prevent any escape around the structure, was deemed too great to render its construction advisable for the present, at least, especially as the volume of increased supply thus secured was so indefinitely known.

The expense of a similar structure for the San Gabriel River would probably be greater than for Los Angeles River, as the gap in the hills where it would be located is much wider.

The project of building a submerged dam in the Santa Ana River, at Bedrock Cañon, appears more feasible, if, as is stated, the bedrock at the narrowest part of the stream is but three to five feet below the surface.

In the Arroyo Seco a submerged concrete dam has been built at the Devil's Gate, which has increased the water supply to some extent, but not having reached the bedrock in the center of the gorge, it is not an entire success. It is 22 feet deep below the surface and cost $3,770.

The result of effectually shutting off the percolation of the river at the coast hills by these tight dams would doubtless be to materially ly diminish the supply of all the artesian wells in the lower valley.

Treatment of cienegas for increasing the supply.

Several methods of treating the cienegas for increasing the water supply are in use. One of these is to strip from the surface the thin layer of peat and moss which overlies the gravel, allowing the water to flow out more freely. In some cienegas the peaty formation is not more than a foot or two in thickness, and may be readily stripped off. Another method is to intersect the cienega with blind drains, filled with brush and poles, and covered with earth. This method is found to answer well, and to facilitate the more rapid escape of the water, largely increasing the supply.

A third method is to bore artesian wells in and around the cienega. This has been tried at Pomona, and near San Bernardino, with success. The wells do not usually require to be more than thirty or forty feet in depth, and are quite certain in securing a flow. Where a cienega exists on ground having a steep slope, or on the crest of a terrace, as in the San Gabriel Valley, these wells could doubtless be greatly increased in discharge by the use of a siphon pipe, connecting with the casing of the well, and leading to the lower ground, practically increasing the head or pressure to the extent of the weight of one atmosphere.

Comparatively little has been done as yet in the way of enlarging the supply of water from the numerous cienegas throughout the country, but the possibilities in that direction are great, and must in time be largely developed. They are all owned by private parties, who are developing them gradually, as their needs require, and do not care to increase the supply faster than they can use it, lest their neighbors occupying lower ground shall acquire permanent rights in the surplus water that might flow to them.

A fourth method of developing water is suggested by the unfailing stream now pouring from the railroad tunnel through the San Fernando mountains. No trace of this stream is said to have appeared on the surface prior to the construction of the tunnel. This method is not new, for it is stated on reliable authority that in Persia tunnels of incredible length, carried sometimes to a distance of twenty to thirty miles, are frequently excavated for the purpose of developing water for agricultural and domestic use.

CHAPTER II.

DESCRIPTION OF WORKS.

For convenience the general description of the various irrigation canals will be grouped in the order named in the following tables, which convey approximate estimates of their length and the acreage irrigated in 1879.

Los Angeles River system.

Name.	Length—in miles.	Cost main works.	Acres irrigated—1879.	Remarks.
High service—Main supply ditch	1.3		7,760	Includes area irrigated outside city limits.
High service—East side ditch	16.0			
High service—West side ditch	13.6			
Low service—Zanja Madre and branches	29.8			
Low service—Zanja No. 7	7.0			
Chavoya ditch	1.0		80	Private ditch.
Feliz ditch	1.75		100	Private ditch.
Chavez ditch	2.0		60	Private ditch.
Totals	72.45		8,000	

Upper San Gabriel River system.

Name.	Length—in miles.	Cost main works.	Acres irrigated—1879.	Remarks.
Azusa Canal and branches	30		2,640	
Duarte Canal and branches	12		1,265	
Peck's ditch	2.5			A small winter ditch.
Totals	44.5		3,905	

Lower San Gabriel River system.

Name or Source of Supply.	Length—in miles.	Cost.	Acres irrigated—1879.	Remarks.
New River—No. 1	2			
New River—No. 2, Temple ditch	3			
New River—No. 3, Strong's ditch	2		1,400	
New River—No. 4, Rincon ditch	3			
New River—No. 5, Cate ditch	4		1,073	
New River—No. 6, Standifer ditch	5.5		1,139	
New River—No. 7, Banta ditch	3		690	
New River—No. 8, Nos Nietos ditch	7.5		1,350	
New River—No. 9, Little Lake ditch	7		1,200	
New River—No. 10, Stout's ditch	2.5		921	
New River—No. 11, Section Line ditch	4		*	
New River—No. 12, Arkansas ditch	1		200	
New River—No. 13, Washburn ditch	1.5			
New River—No. 14, Artesia ditch	4		900	
New River—No. 15, Bixby ditch	3		400	
Old River—No. 16, Repetto's ditch	1		100	
Old River—No. 17, Arroyo ditch	9		4,200	
Carried forward	63		13,573	

* Included in No. 9.

Lower San Gabriel River system—Continued.

NAME OR SOURCE OF SUPPLY.	Length—in miles.	Cost.	Acres irrigated—1879.	Remarks.
Brought forward	63		13,573	
Old River—No. 18, Foster's ditch	3		110	
Old River—No. 19, San Antonio ditch	4		1,400	
Old River—No. 20, Ryan ditch	2.5			
Old River—No. 21, Bixby's ditch	5		60	
Old River—No. 22, Cerritos ditch	3		440	
Old River—No. 23, Colony ditch	2		1,000	
Total of Nos. 1, 2, 4, 13, and 20			2,720	
Totals	82.5		19,303	

Lower Santa Ana River system.

NAME OR SOURCE OF SUPPLY.	Length—in miles.	Cost.	Acres irrigated—1879.	Remarks.
Santa Ana Valley Irrigation Co's Canal	20.5	$62,000	6,400	
Cajon Irrigation Company's Canal	14	80,000	1,500	
Yorba's ditch	3		100	
Anaheim Water Company's Canal	9		1,750	
Totals	46.5		9,750	

Upper Santa Ana River system.

NAME OR SOURCE OF SUPPLY.	Length—in miles.	Cost.	Acres irrigated.	Remarks.
North Fork ditch	8		1,000	
South Fork ditch	16		335	
Camp Carlton ditch	5		300	
Wells' ditch	1		40	
Parrish ditch	1.25		80	
Hunt's ditch	1.50		165	
Agua Mansa ditch	2		200	
Upper Riverside ditch	14	$211,000	4,000	
Lower Riverside ditch	13			
Trujillo ditch	1		200	
Jurupa ditch	4		375	
Linville ditch	1		75	
Soucal ditch	0.75		200	
Yorba's ditch	4.5		500	
Cota's ditch	3		265	
Miscellaneous	10		500	
Totals	76		8,935	

Streams from the Sierra Madre and San Bernardino Mountains.

Name or Source of Supply.	Length—in miles.	Cost of work.	Acres irrigated.	Remarks.
Verdugo Cañon—three ditches	8		240	
Arroyo Seco—Pasadena works	3.15	$25,000	500	
Arroyo Seco—Lake Vineyard works	3.2		695	
Arroyo Seco—Monk's ditch	2	10,000	None.	
Precipico Cañon—Crank ditch	3		200	
Davis' Cañon—Sierra Madre Villa w'ks	1		70	
Bailey's Cañon	0.5		12	
Little Santa Anita Cañon	0.5		3	
Santa Anita Cañon	1.0			
Sawpit Cañon	2.5		100	
Dalton Cañon	1.5		30	
San Dimas Cañon	3	35,000	30	
San Antonio Creek—Kincaid's ditch	1		40	
San Antonio Creek—Cucamonga Co's ditch	2		30	
San Antonio Creek—Hancock's upper ditch	7		160	
San Antonio Creek—Hancock's lower ditch	4			
San Antonio Creek—San José ditch	7		120	
Cucamonga Cañon flume	2.75	35,000	50	
Clark's Cañon ditch	1.5		40	
Reid's Cañon ditch	3		40	
Garcia's ditch	3.5		80	
Sainsevain's	1.5		30	
Lytle Creek—Hale & Perdue's ditch	1.5		30	
Lytle Creek—Anderson's ditch	1.0		30	
Lytle Creek—San Bernardino ditch	9.0		1,500	
Cajon Pass Creek				No information.
Devil's Cañon				No information.
Twin Creeks				No information.
City Creek ditch	1		65	
Plunge Creek ditch				No information.
Mill Creek ditch	10		700	
Lower Ucuipa and San Timoteo	3.5		700	
Totals	88.6		5,495	

Coast Range Streams.

Name or Source of Supply.	Length—in miles.	Cost of work.	Acres irrigated.	Remarks.
Puente Creek—Phillips' ditch	0.25		20	
Puente Creek—Rubottom & Beach's ditch	1.0		14	
Puente Creek—Fryer ditch	.25		16	
Puente Creek—Currier ditch	1.25		70	
Puente Creek—Quintana ditch	3		250	
Puente Creek—Ybarra ditch	2		200	
Puente Creek—Chavez ditch	1		60	
Puente Creek—T. Rowland's ditch	2		200	
Puente Creek—J. Rowland's ditch	2.5		260	
Puente Creek—Workman's ditch	1		60	
Puente Creek—Puente Mill ditch	1		30	
Santiago Creek—Oge's ditch	4		500	
Santiago Creek—Santiago Co.'s ditch	2		250	
Temescal Creek—Several ditches	5		150	
Ditches at San Juan Capistrano	5		400	
Totals	29.75		2,480	

Cienegas of Los Angeles and San Bernardino Counties.

Name or Source of Supply.	Length—in miles.	Cost.	Acres irrigated.	Remarks.
Los Angeles County.				
Alhambra tract, pipe, etc	1.6		125	
Alhambra addition, pipe, etc	1.25	$3,600	280	
Mission ditch	2		295	
Bacon's cienega			70	
Stoneman's cienega			200	
Oak Knoll cienega			30	
Wilson's cienega			20	
Shorb's cienega			150	
Winston's cienega			40	
Ford's cienega			25	
Titus' cienega			60	
Rose's cienega			400	
Chapman's cienega			100	
Baldwin's, 3 cienegas			1,400	
Pomona ditches			502	
Ballona Creek ditches	8		800	
Centinela Rancho cienega			100	
Glassell's cienega, Verdugo Rancho			250	
San Bernardino County.				
Cucamonga Vineyard Co.'s ditch	1		400	
Edendale Co.'s ditch	1.5		150	
Rancheria ditches	2		200	
Colton Land & Water Co.'s ditch	3.5		125	
Meeks & Daley ditch, Warm Creek	4.5		400	
Ditches on Jurupa, Chino and Rincon Ranchos			500	
Total number of acres			6,622	

RECAPITULATION.

Grouping of Irrigation Systems.	Length—in miles.	Acres irrigated.
Los Angeles River System	72.45	8,000
Upper San Gabriel River System	44.50	3,905
Lower San Gabriel River System	82.50	19,303
Lower Santa Ana River System	46.50	9,750
Upper Santa Ana River System	76.00	8,935
Small ditches from Sierra Madre and San Bernardino Mountains	88.60	5,495
Small ditches from Coast Range Mountains	29.25	2,480
Cienegas in Los Angeles and San Bernardino Counties		6,622
Total		64,490

Los Angeles River System.

The irrigation works of Los Angeles were begun with the settlement of the pueblo, about 1770. One ditch or zanja, called Zanja Madre, conveyed the water to the town, whence it was distributed in smaller zanjas to the irrigated lands. These were extended from time to time by the irrigators, until the present system of distribution was established. These primary distributaries have since been declared public zanjas and are controlled exclusively by the city authorities as far as the city limits extend. In their passage through the town they are exceedingly irregular in alignment, passing under the houses, across private property, and only partially following the direction of the streets. They are quite as irregular in grade and cross-sectional dimensions as in alignment. Indeed the entire distributing system, projected and constructed in the fragmentary, careless and unmethodical manner of the earlier residents, is of the most primitive character, difficult to maintain in repair, and wasteful of water. It was not until 1877 that anything was done by the city authorities looking to a general improvement of the irrigation system. By Act of Legislature, approved February 28th, 1876, the city was authorized to issue $75,000 in bonds, for the purpose of constructing new works, and generally improving the facilities for irrigation, and by Act, approved March 20th, 1878, permission was granted to issue $40,000 in bonds additional. A Board of Consulting Engineers consisting of Messrs. B. S. Alexander, Isaac W. Smith, William Moore, and Chas. E. Miles were employed to assist the City Surveyor in devising a comprehensive system of works for increasing the available water supply and effecting its distribution over the whole city.

They reported in favor of two distinct systems of works, one for the irrigation of the hill lands and that portion of the city elevated above the general plane of the valley, called the high service; the other for the improvement and extension of the low service, irrigating the valley lands. For the high service they recommended the construction of a new ditch on the west side, beginning at a point some 10 miles distant from and 200 feet in elevation above the datum plane of the city. (This datum plane is at intersection of Sixth and Spring Streets, and is 255 feet above mean tide level.) The ditch was to empty into a reservoir to be constructed at an elevation of 175 feet above datum plane. At a point about 3½ miles above the north line of the city they proposed to tap the new ditch, and to carry a portion of its waters across the river in a submerged iron pipe 30 inches in diameter, 2600 feet long, whence it was to be taken into a ditch and conveyed to a reservoir in East Los Angeles, crossing Arroyo Seco, en route, with another pipe of same diameter.

For the low service they recommended the construction of a tunnel in the hillside parallel to the river, 3,600 feet long from the dam at the head (to replace the ditch which formerly run at the foot of the hills, over a porous, sandy bed), one or two distributing reservoirs, and 10,000 feet of conduit of iron pipe, brick, or concrete, below the tunnel.

The cost of these works, including two storage and one distributing reservoir, was estimated at $150,252.

These recommendations were not fully carried out, although they were generally followed. A ditch that had been constructed by a

corporation known as the Canal and Reservoir Company, on the west side of the river, including a reservoir of about 20,000,000 cubic feet capacity, was purchased by the city and enlarged. The reservoir was increased near four-fold in capacity. The east side ditch, tapping the main supply canal, was constructed, but flumes were substituted for iron pipes at the crossing of Los Angeles River and the Arroyo Seco. A new reservoir was also built in East Los Angeles. The tunnel recommended for Zanja Madre was reduced in length to 3,320 feet, and from the lower end of the tunnel, where the sand boxes are located for collecting and sluicing out the sand brought in by the water, the zanja was lined with concrete for a distance of 3,500 feet. Concrete pipe was laid for a short distance in Zanja 8, and 8,000 feet of redwood flume was built in Zanja 3. All these various works have effected a considerable saving in water. The cost of the improvements are given as follows, in a report dated February 20, 1879:

For low service works	$29,835 88.
For high service works, west side	29,739 21.
For high service works, east side	39,425 11.
Total	$99,000 00.

Since this report about $8,000 has been expended on work completed during the past year.

In inspecting these various works, one cannot but wonder why the tunnel should have been constructed. It saved no grade, for it discharges into Zanja Madre at the same elevation that the former ditch had attained. It is cut in soft shale rock, which is constantly caving, aided by the percolation from a ditch on the hillside directly above it, already having required to be arched with brick for several hundred feet. An iron pipe or concrete conduit in the old ditch at the foot of the bluffs, would have been less expensive, more readily accessible for repair, and would have effected the same object.

The two dams by which water is diverted into the main supply high service canal, and into the low service tunnel, are simple and inexpensive structures, consisting of square posts, 10x10 inches, driven into the sand about ten feet apart, connected by a sill of same size, placed horizontally between them at the level of the river bed. The posts stand about three feet above this sill, and have grooves in which are placed movable planks to raise and divert the water. These are removed in times of flood. The upper dam is 256 feet in length, and is located diagonally across the stream, on the line between the Providencia and San Rafael Ranchos.

Private ditches from Los Angeles River.

Aside from the ditches belonging to the Los Angeles City system, there are smaller ones diverting water from the river above the city, and belonging to private parties. Of these the Feliz and Chavez ditches are on the west side of the river, and the Chavoya ditch on the east side. They have been in existence a great many years, but the city authorities deny their right to use water, and last summer caused them to be closed by force. The total length of all the irrigating ditches taken from the river, including the principal distributaries extending beyond the city limits, is about 72½ miles.

Upper San Gabriel District.

Two ditches are taken from the San Gabriel River at the point where that stream leaves the Sierra Madre mountains. The one on the east side of the river is called the Azusa ditch, and supplies the settlement on the Azusa rancho, consisting of about 150 individual irrigators. Its total length, including branches, is about 30 miles. At the head it is 5 feet wide on bottom, 7 feet on top, and 2½ feet deep, with a grade of great irregularity, but having a general fall of about 60 feet per mile, dashing over its bed of bowlders with great velocity. The upper part of the ditch was built in 1841. The lower portion is of more modern construction. At the time of my visit, in May, '79, it was carrying 21.8 cubic feet per second. In September, I was informed that the river ran entirely dry at that point. The supply is, therefore, very variable in amount. It is the intention of the land owners of the district to construct a new ditch from the same point to supplant the old one, carrying it on lighter grade around the rim of the valley, and covering a much larger body of land. The ditch has no head-gate, and water is diverted into it by means of a rude dam of bowlders, replaced every year.

On the opposite side of the river, at a point about three-quarters of a mile below the head of the Azusa ditch, the Duarte ditch is taken out for the supply of the settlement on the Duarte Rancho. For a considerable distance the ditch occupies the old channel, through which in olden time the Mission Fathers diverted water for irrigation around the Mission San Gabriel, twelve miles distant. In grade and character of bed it is similar to the Azusa ditch—a large percentage of water is wasted in both. It is divided into three branches, the lower of which goes to the Beardsley tract of 225 acres. The original owner of this tract claims and is allowed to divert one-half of all the water in the ditch, while the remainder is divided among the other irrigators of the settlement. The whole length of the ditch and its three branches is about 12 miles. In May, '79, the main ditch carried 10.7 cubic feet per second.

The irrigators in the district claim one-half of all the water in the river, while the Azusa district claims two-thirds of the total volume. The division of the supply is, therefore, in controversy.

Peck's ditch is a small, unimportant one, located on the west side of the river, five miles below the Duarte ditch, and receiving water only in winter and spring when the river discharges more than the upper ditches can carry.

Lower San Gabriel District.

The peculiar character of the lower portion of the San Gabriel River has been described, and its division into two shallow branches at the Paso de San Bartolo, where the valley is contracted by the coast hills, and the water is forced to reappear at the surface, its volume being constantly increased by springs for many miles below the pass. Between the coast range and the sea, no less than 23 ditches, of more or less importance, are derived from the two streams. Seven of these are taken from the west branch, or Old River (four on the west and three on the east side of the stream), while New River, the east branch, supplies water for sixteen ditches (eight on the east side and eight on the west).

It is unnecessary to enumerate them or describe them in further detail than they are shown in the tables, where they are named in the order of their position on the streams. Many of them have been in existence a great many years, but the majority are of comparatively recent construction.

They are all of very similar character. The streams are both so shallow that water is diverted from them without difficulty by means of simple and inexpensive dams of brush and sand, and the slope of the country is so great that the ditches reach the lands to be irrigated in a short distance from their head.

The largest and most important ditch in the district is the Arroyo, which is 9 miles in length, carries 20 to 30 cubic feet per second, and irrigated about 4,200 acres the past season.

The San Antonio Ditch on the west side of Old River is owned by an incorporated association of farmers; the only one in that section which is incorporated.

Lower Santa Ana District.

The irrigation canals of this group are four in number, taking their water from the Santa Ana River below the Coast Range Mountains. Three are on the north side of the river, namely: The Cajon Irrigation Company's canal, the Anaheim Canal, and a small ditch known as Yorba's. The fourth is on the south side of the stream, and is controlled by the Santa Ana Valley Irrigation Company. As these are among the largest and most important of the irrigation works of that country, a detailed description of them is justified.

The Anaheim Canal.

The oldest of them all, with the exception of the Yorba Ditch, which has been in use for several generations, is the Anaheim Canal, constructed in 1857 by a society of Germans organized in San Francisco under the name of the Los Angeles Vineyard Society. The society purchased a tract of 1,165 acres in the Rancho San Juan y Cajon de Santa Ana, together with a proportionate right to the use of the waters of the Santa Ana, enjoyed by the rancho by riparian interest. The tract was laid out into 50 vineyards containing 20.4 acres each, and 64 town lots containing 0.58 acre each, covering the town site of Anaheim. To irrigate this settlement the present ditch was constructed, which was afterwards transferred to the Anaheim Water Company, incorporated in 1859, with a capital stock of $20,000, subsequently increased to $50,000 and divided into 50 shares of $400 each. For some years irrigation was confined to the lands of the society, but subsequently a contract was entered into between the water company and certain outside land owners by which the latter were permitted to run water through the ditch on payment of $3 each, and on agreeing to bear an equal share of assessments for maintaining repairs, and to pay equal rates for water, with the stockholders, but having no voice in the management. In 1878, owing to a scarcity of water, the water company were obliged to purchase one-half interest in the Cajon Irrigation Company's ditch, at a cost of $20,000. The latter ditch, being located higher on the stream, received a more permanent supply. To effect this purchase, the capital stock was increased to $90,000 and divided into 3,000 shares, each share representing one acre of land. Two thousand shares were immediately

subscribed, and the remainder held in reserve. Connection was made with the Cajon canal, at a point eight miles from the head of the latter, and two miles from head of Anaheim ditch, by a flume 6,970 feet long, having a total fall in that distance of 106.88 feet.

The original Anaheim Ditch has a cross-sectional area of about twelve square feet, and a grade of fifteen feet, without drops or overfalls. Its length is eight miles. Running over coarse sandy soil it naturally loses a large percentage of water by percolation. Its banks are protected on each side by willows, whose roots have formed a compact matting on the bottom and sides, resisting the erosion which must otherwise occur in a ditch of that grade running over friable soil. No head-gate has ever been constructed, on account of the unstable character of the river, which here spreads out in a broad bed of quicksand over 1,000 feet wide, with no defined banks whatever to guide it. The sand brought down by the water into the ditch is a constant source of annoyance and expense. Sand-gates have been placed two miles from the head, where for several hours each day the sluices are opened and the accumulated sand washed back into the river channel, but the fall is so slight from the gates that this device is not wholly effective. The original cost of the ditch was about $5,000, but subsequent assessments for repairs have increased that figure many fold. In March last the ditch was running nearly full, while about six weeks later the river was dry for miles above its head, and but for the flume connecting with the Cajon Ditch, Anaheim would have been entirely deprived of water.

The Cajon Canal.

The Cajon Canal is located highest on the Santa Ana River of all the irrigation channels in the district. It heads at Bedrock Cañon, the narrowest part of the pass through the Coast Range, and follows along the face of broken hills for eight miles, before reaching the plateau overlooking the great valley of the coast. Its total length is 14 miles; bottom width, 7 feet; top width, 13 feet; grade, 2.1 feet per mile; theoretical capacity, 78 cubic feet per second; total cost, $80,000. Twenty-five miles of main distributing ditches have been constructed. Three thousand feet of flume were required in crossing deep arroyos in the hills, the longest being 700 feet in length, having a height of 46 feet in center. The work was begun, and eight miles constructed, in 1875, under the direction of the Boards of Commissioners of Water Districts Nos. 1 and 2, organized under the "Bush Act" of 1874, providing for organization of irrigation districts in Los Angeles County. The total amount of assessments voted by the districts for this work was $60,000, of which $40,000 was collected and expended. The Commissioners being unable to collect the remainder, work was suspended in December, 1875. The following spring a company was incorporated, with a capital stock of $200,000, under the name of the Cañon de Santa Ana Water Company, organized by the owners of the Stearns Ranchos, whose lands had formed half of the two districts, and whose assessments for building the canal had been paid in full. The company commenced a suit in the Seventeenth District Court to condemn the property of the water districts, including the strip of land on which the ditch was located, and obtained judgment by default. No further active steps were taken by the new company, but they have claimed, and still claim, to be in possession of the canal.

In the spring of 1877 another company was organized, with a capi-

tal stock of $25,000, and styled the Cajon Irrigation Company, consisting of a number of individual land owners in the district. Under the direction of this organization, work was resumed and carried to completion at a further cost of $40,000. In the fall of 1878 one-half interest in the ditch was sold, as before stated, to the Anaheim Water Company, for $20,000.

The water supply at the head of the ditch is usually abundant, but is said to have been less during the past season than has ever before been known. The diversion is made by means of temporary wing-dams of brush and sand. The head-gate of the canal is cheaply made of wood, placed against the rocky cliff forming the north wall of the cañon. The fall of the river through the cañon is about 30 feet per mile. Its channel in the narrowest place is about 125 feet wide and two feet deep.

The Santa Ana Canal.

The Santa Ana Valley Irrigation Company's canal was originally projected as a private ditch, in 1870, for the purpose of irrigating lands in the Rancho Santiago de Santa Ana, belonging to Glassell & Chapman, and now covered by the settlement of Orange. It was used to some extent for several years, and in 1874 the ditch was extended to reach the new settlements of Santa Ana and Tustin City, which had sprung up on the lands adjacent to Orange, and were included in the district. At this time the ditch was incorporated, with a capital stock of $30,000, under the title of the Semi-Tropic Water Company. August 6th, 1877, a new company was incorporated, with a capital stock of $100,000, consisting mainly of the stockholders in the Semi-Tropic Water Company, who purchased the interest of the old company, in consideration of payment of its secured debts, amounting to about $5,000. It was styled the Santa Ana Valley Irrigation Company. Immediately after its organization it proceeded to enlarge and reconstruct the old canal from a cross-sectional area of 10 square feet to 45 square feet, increasing the grade from 28½ inches to 45 inches per mile. This work was completed in the fall of 1878, at a cost of $44,000. The cost of the original ditch was $18,000. As at present constructed, the canal has a length, including main branches, of 20.5 miles; bottom width 12 feet; top width 18 feet; depth, 3 feet; theoretical capacity, 114 cubic feet per second.

For the first one and a half miles the canal passes over a porous, sandy loam; the remaining distance the soil is a stiff, clayey loam, mixed with gravel. Eight miles from its head the canal is taken through a spur of the foothills by means of two tunnels, of 200 hundred and 600 feet respectively, cut in sandstone. On leaving the last tunnel the water is divided; one ditch skirting around the rim of the valley, and the other making a nearly vertical fall of 56 feet, and passing across the valley through Orange to Santa Ana.

As an illustration of the peculiar character of the river at the head of the canal, and indeed throughout its lower course, it is related that on one occasion a loaded wagon stuck in the quicksands and was left over night while the teamster went for assistance. In the morning it had disappeared from sight and was never seen again.

These moving sands are constantly drifting into the canal. When water is abundant it is customary to keep the sand-gates open slightly at the bottom to sluice out the sand, which is arrested by a board placed across the ditch below the outlet gate. In summer, however,

the sand is allowed to accumulate above the gates, and is sluiced out by discharging the whole volume of the ditch through them for a short time each day.

Upper Santa Ana District.

The North Fork Ditch.

As the Santa Ana River emerges from its rock-bound cañon into the Valley of San Bernardino, its waters are divided into two ditches, one on each side of the stream. The North Fork Ditch, on the right bank, is eight miles in length, and of irregular cross-section. Its bed is of bowlders, over which the water flows with great velocity, down the steep slope to the valley. The ditch was constructed in 1858, and is now owned by an association of 21 farmers, living north and east of San Bernardino. Water is distributed every ten days, each stockholder having the use of the whole volume of the ditch for a certain number of hours, from 1 to 30, according to the respective interests of each.

South Fork Ditch.

The South Fork Ditch, on the opposite side of the stream, claims five-ninths of all the water in the river. The original ditch built in 1858 or '59 is 8 miles long, and is of similar character to the North Fork Ditch. In 1878 a new ditch was constructed on higher ground, and of more uniform grade and cross-section. It is called the Sunnyside division of the South Fork Ditch. It is of the same length as the old ditch. Both are in use, but the new ditch more than the old. They derive water through one channel at the head. The grade of the Sunnyside Ditch is 17 feet per mile for the first 2 miles, then 75 to 80 feet per mile, for the next 2 miles, and 100 feet per mile the remaining distance. Two miles of the ditch on the heaviest grade and most porous and friable soil is paved with cobble stones, laid dry on the bottom and sides. The cost of the new ditch was $6,000.

Water is diverted into both the North and South Fork Ditches by means of the simplest kind of a barrier of bowlders, and both are devoid of head-gates.

I shall not attempt to describe all the small ditches taken from the Santa Ana River in the upper district. Individually they are comparatively unimportant, although they irrigate considerable land in the aggregate. They are named in their proper order descending the stream, in the foregoing tables.

The Riverside Canals.

The two canals supplying the Riverside settlement, are, however, worthy of special notice, as they are the largest and most systematically constructed irrigation works in the county. The upper canal was commenced October, 1870, and completed a distance of 7¼ miles in the fall of 1871, by the Southern California Colony Association. A few years later it was extended to its present terminus, 14 miles from the head. It is 8 feet wide on bottom, 14 feet on top, and 2½ feet deep, having a theoretical capacity of 70 cubic feet per second. The original cost was $56,000 for the first 7¼ miles. The canal head-works are located at the point of a granite hill, where a dam of brush and rock 900 feet long, 30 feet wide, and 2 feet high has been thrown diagonally across the stream. The head-gate is placed in a solid rock cut 200 feet from the dam, and 500 feet further down is another

regulating gate. The latter serves as an outlet sluice for discharging sand back into the river. The flow of sand is so great that the outlet sluices are opened for several hours each day, which has the effect of keeping the canal entirely clear below the gates. For three miles from the head the canal is cut in a hillside of soft granite, when it emerges upon a smooth plateau elevated above the river 50 to 100 feet, and composed of red clayey loam of great depth. On this plateau, whose soil is found to be so admirably adapted to the growth of trees and vines, when irrigated, is located the settlement of Riverside, extending for 10 miles or more, parallel with the river, which flows in a narrow valley at the base of the plateau.

In 1874 the Riverside Land and Irrigation Company succeeded to the property of the Southern California Colony Association, and in 1875 constructed a second canal to supply the increasing demand for water. This was built on a lower level, commencing at a point about two miles below the head of the upper canal, and following nearly parallel with it down the plateau for 12 miles. It was given a bottom width of 8 to 10 feet; top width 15 feet; depth 3 feet; grade 3.7 feet per mile for 5 miles, and 4.22 feet the remaining distance. There was expended on this work and on the extension of the upper canal about $130,000. In addition to this sum, $25,000 has been expended in improvements upon both the canals, including distributing ditches, which are all built by the company. The distributing system is laid out with great regularity. At each cross-street running nearly at right angles with the direction of the canals, a distributing ditch is built, following one side of the street to the edge of the plateau. The streets are just half a mile apart. The slope of these cross-streets toward the river is 20 to 40 feet per mile, necessitating the construction of numerous overfalls in the ditches to check the velocity and prevent erosion.

A number of expensive flumes have been required on the canals, the longest being those over the Tequisquite Arroyo, a broad gulch intersecting the plateau.

The cost of maintaining the canals and distributing water is very great. The growth of moss and joint-grass in the canal beds is a constant annoyance, necessitating a thorough cleaning every few weeks, to prevent their becoming choked.

Irrigation Ditches from minor Mountain Streams—Sierra Madre and San Bernardino Mountains.

A glance at the tables under this heading is sufficient to show the importance of the numerous small streams issuing from the mountains, at intervals, from San Fernando to San Gorgonio Pass, in making up the irrigation system of Los Angeles and San Bernardino Counties. There is, perhaps, no portion of the State where small streams of water are so fully utilized and made to do so much. I shall not mention them all, but refer to the tables, where they are named in their order from west to east, through both counties.

Pasadena Irrigation Works.

The Pasadena irrigation works from Arroyo Seco afford an example of extreme economy in utilizing a small supply which is worthy of general imitation. The water is taken into a small flume at the head, 700 feet long, and delivered into an iron pipe 3 miles in length,

by which it is conveyed to the colony and discharged into a double reservoir having an aggregate capacity of 3,000,000 gallons. The pipe is 11 inches in diameter at the head, diminishing to 7 inches at the lower end, and having a total fall of 63 feet. From the reservoir the water is conveyed throughout the colony in iron pipes provided with hydrants at each lot. The works were built at a cost of $25,000 by an association of colonists, organized with a capital stock of $50,000. The association originally purchased 3,700 acres of land on the Rancho San Pascual, together with the water right in the Arroyo Seco. Some 1,500 acres were laid off in tracts of 15 and 7½ acres each, and provided with facilities for irrigation. The remainder, consisting of wood-land and land which is mostly non-irrigable, is held in common by the stockholders. The whole of the 1,500 acre tract, on the plateau overlooking Arroyo Seco, is occupied, planted to fruits and vines, and under a high state of cultivation, although but one-third of it is estimated as actually irrigated.

The Lake Vineyard Association Irrigation Works.

The Lake Vineyard Colony, adjoining Pasadena on the east, is supplied by an expensive concrete ditch 17,000 feet long, leading from Arroyo Seco and discharging into three large receiving reservoirs, whence it is distributed through the colony by means of iron pipes. The same association of capitalists who constructed these works, and have sold the land to its present occupants, own another tract further down the valley, called the "Alhambra Addition," which is supplied with water from springs rising in a gulch at the rim of the plateau, and conveyed to the land by means of an iron pipe 1⅝ miles in length, discharging into two reservoirs, having a capacity of 3,000,000 gallons each. The distributing system is similar to that of the upper tract. The total cost of the work for these two tracts was $45,193, or $30 per acre for the 1,500 acres now provided with distributing pipes. There are 4,200 acres of irrigable land in the two tracts, and when the distributing system is extended over the whole area, the average cost will be much reduced. The water rights are held by the association by whom the works are managed, and the water sold to the irrigators. Before the works were constructed the land sold for $2 50 per acre. It is now said to be worth $100 per acre, unimproved.

Sierra Madre Villa Works.

The Sierra Madre Villa, a little stream not exceeding six miner's inches in volume, has converted a waste spot of land, a few years ago overgrown with sage brush and chapparal, into a lovely orange orchard. One-half interest in this stream was sold for $5,000. The water is conveyed in a small flume for nearly a mile, the lower portion having a slope of 960 feet per mile. A reservoir at the Sierra Madre Villa holding 100,000 gallons, stores up the night water for use in the day-time. The distribution is effected by iron pipes.

San Dimas Cañon Works.

The works from San Dimas Cañon consist of a cement pipe five inches in interior diameter, carried for three miles along the face of the gravelly cliff on the east side of the cañon to the plateau at the base of the mountains, where the lands to be irrigated are located. The pipe was constructed last year, and was not in complete working

order at the time of my visit. It is laid on a grade of 23 feet per mile, and is arranged with open stand pipes three feet high, placed at intervals of about 1,000 feet, for the purpose of giving relief outlets to the water, and preventing the pipe from taking too great pressure. It is owned by six individuals, and is expected to irrigate over 700 acres of land. In flood the stream carries an enormous volume, but in spring and summer the supply is reduced to one or two cubic feet per second. The water right cost $1,000, and the works, including two small reservoirs, cost $3,500. If the pipe accomplishes all that is expected of it, the system will prove one of the most economical of all the work thus far projected.

Ditches from San Antonio Creek.

San Antonio Creek, on the boundary line between Los Angeles and San Bernardino Counties, is one of the largest streams issuing from the mountains. Its usual summer flow at the mouth of the cañon is from ten to twenty cubic feet per second. A portion, at least, of the water which sinks in the mountains reappears on the opposite side of the valley, at the foot of the Coast Range, forming the cienegas and moistening the swampy lands on the Chino and Rincon Ranchos, and discharging therefrom quite a large volume into the Santa Ana River. Two ditches claim all the waters of this stream. The San Jose Ditch, on the west or right hand side of the stream, heads near the mouth of the cañon, and is seven miles in length. It goes tumbling down a grade of 100 @ 200 feet per mile, over a bed of bowlders, wasting a large percentage of its water before reaching the lands irrigated. Its owners, Messrs. Loop & Messerve, contemplate building a flume in the ditch to stop the waste.

The Cucamonga Land Company's ditch, on the east side, is about two miles in length, and is but little used.

There are four other ditches from the creek, two in the cañon, irrigating small tracts, and two below. The latter, belonging to Henry Hancock, claim waste water, and are used for irrigating lands near the railroad, seven miles away from the mouth of the cañon.

None of these ditches are of special interest except for their heavy grades, their irregularity of construction, and wastefulness of water.

Cucamonga Cañon Works.

The waters of Cucamonga Cañon, next east of San Antonio Creek, are partially utilized for irrigation by one ditch of recent construction, built by the Cucamonga Homestead Company for the purpose of taking water out upon a tract of land situated at the base of the mountain, directly north of the village of Cucamonga. The works are of the most expensive character, consisting of a concrete dam or basin at the head, and a flume two and three-quarter miles in length, placed upon a shelf graded in the face of the high gravel cliff forming the eastern side of the wild and rugged cañon. The flume is four feet wide and three feet deep, with a grade of 48 feet per mile, and a theoretical capacity of 75 cubic feet per second. The total cost of the work was $35,000. It was built about five years since, but has been little used.

Smaller ditches east of Cucamonga.

The ditches receiving their supply from the small cañons between Cucamonga Cañon and Lytle Creek are comparatively unimportant.

They are small and irregular, and as they dash down the steep, rocky plateau from the mountain's base, they are almost indistinguishable from natural rivulets. Sainsevain's ditch, composed of a well-made artificial channel of concrete, leading to a reservoir of the same material, is an exception. The cost of the ditch, which is, however, but six inches wide and six inches deep, was ten cents per foot.

Lytle Creek ditches.

Lytle Creek is the largest of the mountain torrents emptying into San Bernardino basin, with the exception of the Santa Ana River. The principal ditch from the stream is taken out near the mouth of the cañon on the west side, and after following the plateau for several miles, where a portion of its waters are diverted for irrigation, is carried across the broad, rocky channel of the creek to the Town of San Bernardino. The grades and cross-sectional dimensions of the ditch are of the most irregular kind. For the first few miles the grade descending the plateau is over 200 feet per mile. Where it crosses the broad wash of the creek before reaching the town, it leaves the plateau in a cascade 30 to 40 feet high. No overfalls, drops, or weirs have been constructed to take up the excessive slope, nor have any measures been taken to save the waste by percolation. The ditch has numerous branches, owned by independent associations of irrigators. The total number of irrigators owning interests in the ditch and its branches is about 90. The periodical rotation varies upon each of the branches. For example, the rotation on the upper and middle district branches is made every eight days; the lower district, every six and one-half days; the Henderson branch, every twelve days; the Huston & Suverkrup branch, every eight days; and the waste water ditch, every nine and one-half days. The method of dividing the water between these various branches I could not definitely ascertain. I am under the impression that when the supply is scanty each branch is given the whole volume of the stream for a portion of the time each week, or for a certain number of days each month. When water is plenty, each diverts its proportion as near as it can be guessed at, and a constant stream allowed to flow in all.

Mill Creek Ditch.

The Mill Creek Ditch, on the eastern side of the valley, was constructed in 1820 by the Jesuit Fathers who founded the Mission San Bernardino. The ruins of the old mission can still be seen in a few crumbling walls of adobe, but the orange groves and vineyards planted by them remain as more enduring monuments of the work of the padres. The ditch follows a natural depression in the valley, and now so closely resembles a mountain brook, flowing over its winding bed of bowlders, and lined on either side with mountain alders, that a question arose a few years ago as to whether it was really an artificial channel or the natural outlet of Mill Creek. The question was decided on competent testimony by the Courts. The direct, broad, and plainly marked true channel of the creek joining the Santa Ana River, several miles above the old mission, was conclusive proof that the stream did not naturally seek its present outlet. The waters of the ditch are controlled by eighteen individual farmers holding first rights to its use.

Lower Ucuipa Ditch.

The Lower Ucuipa Ditch is taken from Ucuipa Creek, near the junction of that stream with San Timoteo Creek, and irrigates a number of small farms in San Timoteo Valley. The estimate given in the tables of the land irrigated by the ditch includes all irrigated land in the valley from San Gorgonio Pass to its mouth, there being a number of small ditches from San Timoteo Creek and cienegas, which have not been located and specified by name.

This concludes the review of the ditches from the minor streams of the Sierra Madre and San Bernardino Mountains. With the exception of the one last named they are very similar in general characteristics. They flow down steep slopes, over beds of bowlders, with great irregularity of grade and form, except where systematic works have been constructed for checking the excessive loss of water which results from such irregularity. In the aggregate they supply a considerable volume of water for irrigation, but the loss before reaching the irrigated lands is enormous, and must at some time lead to the adoption of more effective measures for its prevention and the more perfect conservation of the supply.

Ditches from Coast Range streams.

Among the Coast Range streams I have classified that branch of the San Gabriel River known as San José, or Puente Creek, as it has no direct connection with the Sierra Madre. It is a phenomenal stream, lying in the center of a narrow, fertile valley (occupied by the Southern Pacific Railroad as a portion of its route from Los Angeles to San Bernardino), without any head or well defined feeders, but fed by springs rising in its deep, narrow bed. These springs, which first appear a short distance above Spadra, supply water for a number of small ditches distributed at intervals down the valley on either side of the creek. In the tables they are named in their proper order—descending the stream. They do not require special description, as they are all similar; being simple earthen channels of small dimensions and light grades. The soil of the valley is a black, stiff loam, requiring but little water to produce the crops of corn, potatoes, and beans, which form the staple of the productions.

Santiago Creek ditches.

Santiago Creek is a stream heading among the highest peaks at the culminating point of the Coast Range, where the Counties of Los Angeles, San Bernardino, and San Diego have a common corner. It flows northward, joining the Santa Ana River below the settlement of Orange. As it emerges from its cañon its waters are divided into two ditches, which are used for irrigating young orange groves, etc., adjoining the Orange colony.

Ditches from Trabuco and San Juan Creeks.

In the southern portion of Los Angeles County two streams rising in the Coast Range and flowing westward to the sea, unite in a broad and beautiful valley a few miles before reaching the ocean, furnishing water for the irrigation of several hundred acres in the neighborhood of the old mission of San Juan Capistrano. The ditches by which the water is diverted are six in number, and are all small, having an aggregate length of about five miles.

Ditches from Temescal Creek.

Temescal Creek, in San Bernardino County, the high water outlet of Laguna Temecula, furnishes a small supply for half a dozen little ditches located at those points where the water that usually hides below the surface is brought to the top of the ground by an interposing bed of rock across the channel.

Ditches from Cienegas.

In the chapter on water supply I have sufficiently described the general characteristics of the cienegas to render further reference to them unnecessary. The ditches from them, with the exception of three or four along the San Gabriel fruit belt, where the water is conducted in iron pipes, consist of open earthen channels of small dimensions, with nothing of special interest about them requiring to be particularized. They are highly important to the localities enjoying their use, and add largely to the area of irrigated land, and to the wealth of the country. The constancy of their flow throughout the year render them of especial value.

CHAPTER III.

PRACTICE OF IRRIGATION.

Methods of irrigation—Duty of water.

Artificial irrigation has been practiced in Los Angeles and San Bernardino Counties ever since the earliest settlement of the country, more than 100 years ago, by the Jesuit Fathers. These pioneers of Californian civilization selected the sites for their missions with sagacity and good judgment, locating them in places where water was most abundant and where irrigation could be most readily carried on. There are evidences to show that they carried out an extensive and well planned system of irrigation works. The traces of their ditches, stone aqueducts, and dams, whose masonry, where undisturbed, remains as perfect as when it was laid, are frequently met with, but they are now generally superseded by more recent works.

It is natural that, where irrigation has been so long in use, where the water supply, as compared with the large area of cultivable land, is so limited, and where the character of the products raised by irrigation are generally so valuable, one should expect to find the art of irrigation brought to a high degree of perfection, and the economical use and conservation of waters carried to its furthest extreme. This is, however, only true in a measure. The distribution of the water supply in many comparatively small bodies, frequently having its source upon lands owned in large tracts under Spanish grants, or attached thereto by old riparian rights, and the monopolizing of the waters by individuals through these means, and by prior appropriations of considerably greater supplies of water than were absolutely needed by them, and, in short, the complicated system of water rights, involving absolute ownership of water, which have arisen in an absence of

adequate laws providing for the equable distribution of that precious element, has tended to a careless prodigality in its use by those who happened to be possessed of an abundant supply, and the entire deprivation of water privileges by those less fortunately situated. It is chiefly in those localities and communities where the supply is least, and where every means must be taken to eke out the little that is available, that the highest duty of water is attained and the utmost economy and skill is to be observed. Nevertheless, there is much that is instructive and interesting in the methods of irrigation practiced in this section, and, generally speaking, it is doubtless true that irrigation is here further advanced and more thoroughly developed than in other parts of the State.

In traveling from one community to another, in the two counties under consideration, it was remarkable to observe how little each appeared to know of the extent of irrigation, or the systems, peculiarities, and local regulations prevailing in adjacent localities. Each community had developed a system peculiar to itself, and appeared neither to know nor care of what was going on around them in the same line of pursuit. To a description of these various customs, as they fell under my observation during the course of a somewhat hurried examination, I shall now devote a few pages.

Character of irrigation.

Irrigation is confined almost exclusively to vineyards, orchards of semi-tropical and deciduous fruits, corn, potatoes, alfalfa, and gardens, named in the order of their relative importance. As there are large agricultural communities where attention is given exclusively to the cultivation of semi-tropical fruits, and to viniculture, it is probable that the major part of the irrigated lands are devoted to these products. Cereals are rarely or never irrigated, the reason given being that "it does not pay." Wheat is not a common product on account of rust, and barley is in so little demand, and has generally had so low a market value, that it is not considered profitable to irrigate it, especially as the rainfall in most seasons is sufficient to mature it without irrigation. Corn and potatoes, which are staple productions, being grown in the warmest and dryest season of the year, require irrigation to produce a crop.

Methods of application of water.

The methods of applying water in general use are three:

Flooding by ditches.

First—That of flooding the surface with a thin sheet or layer, distributing it by small ditches, and guiding its direction by hand.

Flooding by compartments.

Second—That of dividing the land into small square compartments, separated by a temporary ridge of earth thrown up with the plow and filled with water, which is allowed to soak away, or after standing a sufficient length of time is drained off into adjoining compartments.

The furrow method.

Third—That of conducting the water across the land by means of a number of parallel furrows, from which the intervening ground is wet by percolation.

Methods used in San Joaquin Valley inapplicable to Los Angeles.

The nature of the crops raised, the steep slope of the ground, and the small quantity of water available, precludes the adoption of the system of dividing the land into large compartments, containing 10 to 100 acres, by check levees following the contour of the surface, as is the custom in the San Joaquin Valley, while the texture of the soil is such that irrigation by seepage from ditches surrounding the fields, which is practiced in the Mussel Slough District of Tulare County, and in parts of Kern County, is impracticable.

The first of the three methods mentioned is used in the irrigation of corn, alfalfa, and potatoes.

Irrigation of orchards.

The second method, which resembles that known as the "English bed-work system," is particularly applied to orchards where the trees are regular distances apart, usually 25 to 30 feet, each tree being in the center of a compartment. The ridges separating them are thrown up with the plow previous to each irrigation, two furrows thrown together being sufficient to form the ridge. As each compartment is filled, the ridge separating it from the next one lower is broken down and the water allowed to pass on, and so on to the end of the row, when the stream is transferred to the next series. Some cultivators throw up a mound of earth around each tree, so as to prevent the water from reaching the trunk, while others excavate a circular, bowl-like cavity around the tree, with ditches connecting them, and after irrigation fill it up again. The latter method is preferred for small trees, and effects an economy of the water, as the portion of the land immediately about the tree only is wetted, leaving the intervening space dry. Older orchards, however, require the thorough saturation of all the soil. It is customary after each irrigation to plow, harrow, and thoroughly pulverize the ground around the trees, to prevent the baking of the surface, keep down the growth of weeds, and maintain the soil in a mellow condition. This treatment renders the land better capable of retaining moisture, and by thorough cultivation adds to its fertility. Experience seems to show, furthermore, that thorough and frequent cultivation is in a measure a substitute for irrigation, especially in orchards and vineyards on tolerably compact and retentive soil, that have obtained a vigorous start by means of irrigation. There are many experienced horticulturists who maintain that irrigation is a positive disadvantage to trees and vines, and should not be practiced if it can possibly be avoided. This theory is being practically tested, with sufficient success in some localities to prove that thorough cultivation at least effects a saving in water quantity used; and I doubt not that by this means the duty of water will in time be largely increased, and irrigation be chiefly practiced for starting young orchards and vineyards and for occasionally wetting the old ones in the dryer portions of the year.

Irrigation of vineyards.

The third method, that of furrow irrigation, is particularly applied to vineyards, small fruits, gardens, and sometimes to corn and potatoes. By the "tapon" system of furrow irrigation, the lateral ditch at the upper side of the field, at right angles to the furrows, is previously arranged with a series of "tapons" or temporary earthen dams, thrown across the ditch at intervals of three or more rows. Openings

are made in the ditch bank at the head of the furrows and the water admitted to the ditch is held in check by the first tapon and turned into the first series of furrows. When these are sufficiently wetted the tapon is torn away, the gaps in the bank are closed, and the water passes on to the next tapon and its series of furrows, and so on to the end of the field. This method is in use more systematically in Anaheim than elsewhere.

In the Riverside settlement the same plan of watering vineyards is pursued, but the means of admitting water to the furrows is differently arranged. Instead of cutting a hole in the ditch bank at each irrigation, a series of short boards (one to each furrow) are permanently fixed in the lower bank of the head ditch. In these boards one or two auger holes are bored, sufficiently large to give passage to a considerable stream of water. The ditch being then filled with water, a large number of streams are kept running at once. By experience the irrigator learns just what quantity of water the vineyard requires and the length of time necessary to let it run. He purchases just sufficient to keep his ditch full, adjusts his regulating gates and lets the water do the rest, no special attention being required. This arrangement saves labor, equalizes the distribution of water, and economizes the quantity.

Hillside irrigation.

Another method of furrow irrigation was observed in a hillside field of tobacco, owned by J. C. Davis, adjoining the Sierra Madre Villa. The slope of the ground was about one foot in five. The furrows followed the contour of the hill on a level, and the water was conducted to them by a portable V flume, descending the hill on its highest ridge in the center of the field. A sliding stop-block in the flume forced the water to overflow at any furrow desired, and when the furrow was filled in both directions the block was slid down to the next furrow and the operation repeated. This is but a modified form of the "tapon" system of Anaheim, specially adapted to steep hillsides where the water could not be easily handled in any other way.

SEASONS OF IRRIGATION.

The season of irrigation extends from about the 1st of March to the 1st of October, commencing a little later than March if the rainy season is prolonged into the spring months and closing earlier than October if the rains set in early, or if there has been an abundance of water through the summer.

It is unfortunate that the season of greatest demand should occur when there is least water—during the hottest and driest months.

Vineyards generally require less irrigation than any other crop, except it be cereals, which, as I have before stated, are as yet but little irrigated. From one to four thorough waterings (according to the nature of the soil), before the fruit begins to form, are sufficient for vines. They are not irrigated later than May or June, until after the crop is harvested, when they are generally thoroughly irrigated once before the advent of winter rains.

There is no especial season for the irrigation of orange trees. Experienced cultivators can tell when the trees need water, and they apply it whenever it may be necessary. Very little irrigation is practiced in the winter months, unless the season be a very dry one.

To illustrate the distribution of demand through the year in the Los Angeles district I present the following table, showing the receipts from sale of water by the City of Los Angeles in each month during the past few years, kindly furnished by Mr. Robinson, City Clerk:

Table of Receipts from Sale of Water—City of Los Angeles.

Month.	1877.	1878.	1879.
January	$113 00	$400 00	----------
February	544 75	48 76	$25 00
March	1,121 00	12 99	264 00
April	1,048 75	----------	1,167 50
May	1,138 50	1,045 25	1,597 00
June	1,387 75	1,547 50	1,509 00
July	1,163 75	1,611 75	1,592 00
August	1,016 75	1,652 75	1,529 50
September	594 00	792 00	1,367 50
October	448 25	435 75	408 50
November	176 00	230 50	139 50
December	169 25	267 00	5 75
Totals	$8,921 75	$8,044 45	$9,605 25

In 1876 the total receipts were $8,201 63, of which about $800 was in April, $1,100 in May, $1,100 in June, $1,200 in July, $1,100 in August, $400 in September, $200 in October, and $2,300 in the other five months of the year.

Deductions from the table.

This table shows how directly the rainfall affects the demand. The season of 1877 was a very dry one. The rainfall for the entire previous season was but 5.29 inches, and the necessity for irrigation was early felt, so that considerable water was sold in February, and a large amount in March and April. The following season the rainfall was 21.26 inches, prolonged late into the spring. Consequently, a mere trifle was used in February and March, and none in April, the season proper beginning in June. The table also indicates that general irrigation is over by the end of August. Subsequent sales are more for market gardens, and the final irrigation of vineyards.

If we assume that the discharge of 67 cubic feet per second was maintained throughout these seasons, the receipts of the years named give average values for the season to each cubic foot per second, of $122 41, $133 16, $120 06, and $143 36, respectively.

Value of water compared with other countries.

Compared with the values of water in other countries, these are low. For instance, the Henares Canal, in Spain, is allowed to charge $1,875 per cubic foot per second through the year. In dry seasons an average price on the older irrigation canals of Spain have been as high as $11,000 per cubic foot per second through the year. In Italy the same quantity brings only $75 to $80.

THE DUTY OF WATER.

In the absence of any exact data as to the discharge of the irrigat-

ing canals of Los Angeles and San Bernardino Counties through the season of irrigation, it is impossible to arrive with any sort of definiteness at the duty accomplished by water in the various irrigation districts. We know that the discharge is inconstant for most of the sources of supply, and that the variable quality and characteristics of the soil in different sections causes a great variation in the duty of water. Without having the opportunity to investigate and verify the statements of irrigators regarding water quantity used, I present a few examples taken from different parts of the country for what they may be worth:

1. *The first example* is selected from the City of Los Angeles, where the supply is more nearly uniform throughout the irrigating season than elsewhere. The total available supply of the river, as we have seen, amounted in May last to 78½ cubic feet per second. Of this amount about 11½ cubic feet per second is used on the Feliz Rancho for irrigation, and by the city water-works for the household supply of the city. The amount, therefore, available for the irrigation channels belonging to the city is 67 cubic feet per second. Accepting that as the average discharge through the season (in the absence of more accurate data), the average duty for the 7,555 acres irrigated would be 112.8 acres per second-foot. If we assume that 33⅓ per cent. is lost by percolation and evaporation, the duty accomplished by the amount actually applied would be about 169 acres per cubic foot per second. The Common Council of the city have made an allotment of one "irrigating head" for 2½ hours in each month as the maximum quantity to be used on each acre of land inside the city limits.

The "irrigating head."

It is necessary to explain what is meant by an "irrigating head." The total volume of water in the River Los Angeles is divided into 17 parts, each forming an "irrigating head," and intended to be as nearly equal as possible, giving a theoretical value for each of nearly four cubic feet per second. The means by which the division is made are so crude, however, that I found the heads varying from 2.75 to 4.25 cubic feet per second. Again, the loss by percolation is excessive, and although the head may be four cubic feet per second at the upper end of the canal, it is frequently reduced to two and a-half to three cubic feet before reaching the lands.

The allotment of the City Council would be equivalent to a depth of 0.51 to 0.62 feet over the lands at each irrigation, reducing the duty to 83 to 100 acres per second-foot. Doubtless a majority of the irrigators inside the city limits, who have the prior right to the use of the water over those outside, avail themselves of the full quantity allotted, and accomplish but that low duty over their lands, while the irrigators outside the city, who are obliged to exercise greater economy, obtain a much greater duty from their water, so that the average duty of the whole is probably raised to about 110 to 190 acres per cubic foot per second.

The City Zanjero estimates the average capacity of one irrigating head to be the irrigation of eight acres in 12 hours, which would be equivalent to a rainfall of 0.31 to 0.37 feet over the land, yielding a duty of 192 to 160 acres per cubic foot per second, by the monthly rotation of the irrigations. Presuming that the land is irrigated every 30 days from March 1st to October 1st, which is the principal

irrigating season, the total depth of water applied according to this estimate would be 2.11 to 2.59 feet.

2. In Anaheim, I estimated the average duty of water for vineyard irrigation, during the season from February to June, at 210 acres per cubic foot per second. Vines are irrigated from one to three times during the season. For orchards the duty is somewhat lower, as the trees require more frequent irrigation and greater quantity of water. The soil of Anaheim is a deep sandy loam, very porous, and underlaid with gravel, which rapidly drains away the water applied. The water supply is limited and the utmost economy must be practiced in its use, which doubtless accounts for the high duty attained.

3. In the settlements of Orange, Santa Ana, and Tustin the irrigating head is about two cubic feet per second in the summer, and 2.5 in winter and spring. I was told that the average head of say 2.25 cubic feet per second would flood ten acres in twelve hours, giving an average depth over the land of 0.22 feet, and that one irrigation every 60 days was sufficient for orange orchards and other fruits. If this statement be true the duty of water would be 533 acres per cubic foot per second, and to irrigate the 6,400 acres reported to be irrigated in these settlements would require an average discharge of but 12 cubic feet per second in the supply canal. From the fact that the canal was carrying at the head 45 cubic feet per second in March last, 23.7 cubic feet in May, and (according to measurements furnished by Captain Geo. C. Knox, of Anaheim) 15.9 cubic feet in August, I judge that the average duty is much less. Percolation is not found to be excessive in the canals, and no great amount is allowed to go to waste. The soil is a red clayey loam, mixed with gravel, and is of such a compact texture as to absorb considerable water and retain moisture well. I conclude, therefore, that irrigation is more frequent than stated, that more water is absorbed at each irrigation, and that the average duty accomplished with the water diverted does not exceed say 300 acres per cubic feet per second.

4. In the settlement of Riverside the irrigating head used is from one-quarter to one and one-quarter cubic feet per second. With the latter, which, according to the local measurement is the equivalent of 50 inches, I was informed that ten acres of young orange trees on new land can be irrigated in ten hours. In the hottest part of the season the trees are irrigated every two weeks, and the total number of waterings during the year are about eight. This discharge would cover the land to an average depth of 0.092 feet, performing a duty during the period of semi-monthly irrigation, of 273 acres per cubic foot per second. Older orchards require a greater quantity of water at each irrigation, but less frequent applications are necessary. About six waterings are sufficient for the older trees in the period from February to September. I was told by one irrigator that he could irrigate 100 acres of old trees in thirty days, with a 10-inch stream (0.25 cubic feet per second), giving an average depth of 0.15 feet at each irrigation, or 0.9 feet in six irrigations. The average duty of the water during the season would thus appear to be 400 acres per cubic foot per second. This I judge to be higher than the true average. If, for example, the duty be assumed at 300 acres per second-foot, the amount necessary to abstract from the river for the irrigation of the 4,000 acres now irrigated would be 26 to 27 cubic feet per second for twelve hours a day, (there being but little irrigation at night, the water is either returned to the river through the waste sluices or is wasted at the

terminus.) This corresponds well with the quantity found in the canals by myself in May, when the discharge was 26½ cubic feet per second, and by Captain Knox, in August, when they were carrying 27½ cubic feet per second. I conclude, therefore, that the average duty of water in Riverside is not far from 300 acres per cubic foot per second of the water diverted, and considerably more for that actually applied.

From a carefully prepared estimate made by the water company of Riverside, of the average cost to the farmers for water in 1878, I calculated the average depth of water applied throughout the season (knowing the price and approximately the discharge) to be equal to a rainfall of 1.85 feet, or about 22 inches, which would require an average discharge of 24.9 cubic feet per second for twelve hours each day during ten months of the year.

The soil of Riverside is a red loam, firm, compact, and retentive of moisture, having a depth of 60 to 100 feet, beneath which gravel, bearing the first stratum of sub-surface water, is found.

5. Along the Mill Creek Ditch, San Bernardino, where the soil is sandy and underlaid with gravel, I was informed by one irrigator that eight acres can be irrigated in 18 hours, with six cubic feet per second, equivalent to a depth of 1.11 feet over the whole area. His water right gives him 18 hours water every ten days. To irrigate his 60 acres equally would therefore require 75 days, or 135 hours actual irrigating time, and the duty accomplished by the water would be just 133⅓ acres per cubic foot per second. Another irrigator having the same amount of land, and an equal water right, but with soil rather more porous, informed me that with about the same discharge he could water his whole tract in two weeks—or 252 hours irrigating time, requiring an average depth at each irrigation of 2.08 feet, and an interval between waterings of 140 days. The duty thus accomplished would be 133⅓ acres per cubic foot per second. The equality in duty resulting from the use of unequal amounts of water, in these cases cited, is caused by the difference in the length of periods between waterings.

In both these cases the land was well soaked in the spring, when the discharge of the ditch was much greater than six cubic feet per second, and subsequent irrigations during periods of scarcity were less thorough and confined to frequent wetting of the space immediately about the orange trees, in which the lands were principally planted. It would not be safe to permit the trees on that character of soil to go 140 days, or even 75 days, entirely without water.

The entire area irrigated by the Mill Creek Ditch is reported to be 700 acres. Under an average duty of 100 acres per cubic foot per second, a discharge of 7 cubic feet per second would be required through the season to accomplish the irrigation of that area. Deducting the loss by percolation, which is enormous, I am inclined to think the average discharge actually used for irrigation is not far from that figure, and am thus led to believe that a duty of 100 acres in this section is about what is accomplished with each cubic foot per second used.

6. On the Azusa Rancho, in the Upper San Gabriel district, the usual irrigating head is about 3½ cubic feet per second, which is calculated to be sufficient for the irrigation of 8 acres of corn in 12 hours. Three irrigations are usually required in the period from April to

July, inclusive, giving the greatest interval between waterings of about 50 days. The average depth at each irrigation would thus be 0.4 feet, or 1.2 feet for the season, and the average duty 285 acres per cubic foot per second. Other crops, such as potatoes, beans, etc., probably require more water and more frequent applications, and I judge that the average duty of water on the whole area irrigated by the Azusa Canal (2,640 acres), does not exceed 120 to 150 acres per second-foot, of the amount diverted, and possibly 200 acres, of the amount used. In March last the quantity diverted was 23¼, and in May, 21¾ cubic feet per second. An average diversion of 22 cubic feet per second would give an average duty of 120 acres per second-foot. The soil of the district is a deep sandy loam, highly susceptible of irrigation and retentive of moisture.

(7.) In Pasadena the water supply does not generally exceed 0.43 cubic feet per second, of which about 0.3 cubic feet is now used. With this amount, carefully distributed with iron pipes, and supplemented by thorough cultivation, a very large duty is accomplished, irrigating 500 acres of trees, vines, and gardens, and averaging 1,665 acres irrigated per cubic foot per second. In irrigating orange trees the whole surface is seldom flooded, but the water is confined to the immediate vicinity of the tree, and the quantity used is small as compared to the whole area of the orchard. With 25 "inches," 400 to 500 trees, covering 6 to 8 acres of ground, can be irrigated in 12 hours, equivalent to a depth of less than an inch over the entire surface.

The soil is similar to that of Orange and Riverside, called "red mesa land." It is deep, firm in texture, and having a sufficient admixture of fine gravel to render it mellow when cultivated, and capable of retaining moisture a long time.

8. In the Lake Vineyard settlement adjoining, the supply at the time of my visit was 3.1 cubic feet per second, which was not all used, but which irrigated 695 acres. The soil is precisely like that of Pasadena, and as high a duty can be reached with the same economy.

9. For the Sierra Madre Villa and adjoining property, the supply is but about 0.12 cubic feet per second, with which 70 acres of orange and lemon orchard, vines, tobacco, etc., are now irrigated, giving an average duty of 583 acres per cubic foot per second. There are some 500 acres dependent upon this source of supply, which will ultimately be irrigated by the same economical distribution of water in flumes and iron pipes that is now in use. The soil is somewhat similar to that of other localities on the plateau at the base of the Sierra Madre, but contains less of the red clay.

SUB-IRRIGATION.

10. As an instance of extreme possibilities in the economical use of water, the asbestine system of sub-irrigation, patented by E. M. Hamilton, of Los Angeles, is deserving of notice. Pipes made of a combination of Portland cement, lime, sand, and gravel, with a small admixture of potash and linseed oil,* are laid at a depth of one and one-half to two feet below the surface, parallel to the rows of trees or vines in an orchard or vineyard. In these pipes, on the upper side, is inserted a wooden plug opposite each tree or vine, the plugs

* The stone made by this composition weighs, when dry, 144 pounds per cubic foot.

having tapering holes in the center, one-fourth to three-eighths of an inch in diameter, through which the water finds exit. Each plug is surrounded by a larger stand-pipe, setting loosely on top of the distributing pipe, open at the bottom, and reaching to the surface of the ground, for the purpose of keeping the dirt away from the outlet and rendering it accessible at all times for inspection. The pipes are connected with mains leading from a reservoir. The process of irrigation is unattended by any labor beyond that of turning on the water and shutting it off. The water finds its way through all the outlets, filling the stand-pipes, and slowly percolating to the roots of the plant. No water appears on the surface, consequently the ground does not bake with the heat of the sun, but is kept mellow and moist, and no moisture is lost by evaporation. In the orchard of the inventor, where the system was first tried, I saw three acres of young trees thoroughly irrigated in half an hour with about 400 cubic feet of water, or less than 3,000 gallons. Such an application twice a month is sufficient to maintain a vigorous growth in the trees, which have attained twice the size of adjacent trees of the same age, on the same soil, with the same amount of cultivation, irrigated by the usual method of surface application. Could the same proportion in the use of water be carried out through the season as that of the experiment mentioned, a cubic foot per second would irrigate 9,000 acres. This particular piece of ground, however, like all uplands of the City of Los Angeles, is composed of soil of a heavy texture. Lighter soils and older trees would require more water; but the system, under any circumstances, must effect a very great saving of water over the ordinary methods of surface application, and for orchards, vineyards, and gardens, must come into general use, not only on this account but for the other advantages it possesses—the saving of time and labor, the ease with which the amount applied can be gauged and regulated, the convenience of the pipes for the distribution of liquid manure, and the fact that water is applied by this means beneath the surface, encouraging the roots to grow deep, instead of spreading out near the top of the ground, as they do with surface irrigation.

The cost of the system for an orange orchard is but \$30 to \$50 per acre. The pipes are laid in the position they are to occupy by a simple machine, with which three men may lay 1,600 feet a day. They are, therefore, continuous and without joints.

The system is being introduced generally throughout the State, and is meeting with favor. For the special purposes to which it is adapted it must be looked upon as a valuable aid in the solution of the problem of irrigating large areas with small supplies of water.

CHAPTER IV.

LOSS AND WASTE OF WATER, STORAGE, DISTRIBUTION, MEASUREMENT AND SALE OF WATER.

LOSS OF WATER.

A consideration of the economical measures which have been adopted in some localities for the conservation of water, leads to a reflection on the enormous loss and waste which in other parts char-

acterize its use in irrigation. The Board of Consulting Engineers employed in 1877 to devise and recommend a comprehensive system of irrigation works for the City of Los Angeles, say in their report: "The present system of irrigation in and around the City of Los Angeles is very wasteful. The soil is generally sandy, and the water is conveyed in open zanjas; a large proportion of the water is therefore lost by absorption before it reaches the land to be irrigated. * * From actual measurement made on the main ditch on the 25th July, there was a loss of 33 per cent. of water in a distance of 6,000 feet. There is no doubt in our minds that half the water taken from the river is allowed to run to waste." From the few experiments I was able to make, I am convinced that the above estimate of loss in Los Angeles is not overstated, although since that report was made considerable has been done in the way of stopping the waste. The tunnel on Zanja Madre, 3,320 feet long, in soft rock, and the concrete and masonry lining for 3,500 feet below the tunnel, effect a large saving. On Zanja Three a flume 8,000 feet in length over that portion where great loss had been experienced through the extreme porosity of the bed, has also resulted in considerable saving. There is yet much to be done before all the available water can be utilized.

The greatest loss of water in all that section is observable in those ditches which are derived from streams at points where they issue from the mountains and are conducted in open channels without protection across the rocky, gravelly debris forming the foot of the mountain slope. Of such a character are the ditches in the upper San Gabriel district, derived from San Gabriel River, the ditches taken from San Antonio Creek, Lytle Creek, Mill Creek, Santa Ana River at the mouth of the cañon, and other similar streams. On the San Gabriel River and San Antonio Creek there is considerable hydraulic and placer mining above the heads of the ditches, and the finer particles of clay and soil thus washed down form a puddling for the ditches, which for a portion of the year at least, aids in a measure in lessening the waste.

Paving ditches to prevent loss.

The method adopted on the Sunnyside division of the South Fork Ditch from the Santa Ana for the saving of water and prevention of erosion over that portion where the grade is 80 to 100 feet per mile, was to pave the bottom and sides with cobblestones, laid dry and snugly fitted together. During the latter part of the past season, when other neighboring ditches were nearly dry the greater portion of their length, this one, I was informed, maintained a fair supply. The cost of the paving was comparatively light, not exceeding $1,000 per mile. A movement is on foot for paving the North Fork of Santa Ana and Mill Creek Ditches in a similar manner.

Iron pipes.

The most perfect measure for the prevention of waste is to conduct and distribute the water in pipes. This has been done in several instances, as, for example, the works of Pasadena, Lake Vineyard, and other tracts along the San Gabriel fruit belt.

Concrete lining for ditches.

The next best method is that adopted in Los Angeles, *i. e.*, the lining of the bottom and sides with stone masonry, brick, or concrete,

and is the one best adapted for large ditches, on account of its greater economy in cost. The cost of concreting the Zanja Madre was $1 80 per linear foot, the form being that of a segment of a circle, having a diameter of 5 feet and a depth of 3½ feet. The thickness of the concrete was six inches. The ingredients used were: hydraulic lime, two parts; clean, sharp sand, three parts; pebbles (one inch diameter), four parts; small stone (two to three inches diameter), four parts; large stone (not exceeding five inches diameter), four parts; water to give proper consistency. The lime was not of first quality and the concrete is therefore soft and perishable.

Lake Vineyard concrete ditch.

The longest concrete ditch is that constructed by J. DeBarth Shorb for the Lake Vineyard settlement. It is 17,000 feet long and cost $1 50 per foot. It has the form of a circular segment, four feet across the top and three feet deep. The hydraulic lime used was from a quarry opened by the Mission Fathers and employed in the construction of their masonry about the Mission San Gabriel. It is represented to be of good quality.

Line of improvement for the future.

As the country becomes more densely populated, and the value of water for irrigation increases, many similar improvements will undoubtedly be projected for the prevention of waste. It is simply a question of the value of water. If a cubic foot per second is worth $100, $500, or $1,000 per annum, what amount of money can those benefited afford to spend in saving or producing that amount? In a community like Los Angeles, where thousands of acres of orange orchards and vineyards are dependent upon irrigation to sustain them, water is of more value than the land. Take away the water and the land would greatly deteriorate in value. A prominent citizen of that city largely interested in irrigation, considers a head of water in perpetuity to be worth at least $100,000. Their 17 heads would therefore have an aggregate value of $1,700,000. Viewed in the light of an investment this estimate is exaggerated, as the revenues derived from sale of water do not pay an interest of one-half of one per cent. on that amount of capital, but considering the actual benefit bestowed by the water upon the property enjoying its use its value is probably not overstated.

STORAGE OF WATER.

The subject of the storage of surplus water has deservedly received much attention throughout the Counties of San Bernardino and Los Angeles, where in winter the streams hurry to the sea with large volumes of water, and in summer dwindle to mere rivulets. And as the settlement of the country progresses, and the use of water becomes more extended, the question will continue to be agitated. As yet but little has been accomplished in the way of saving the volume of the winter floods from going to waste. Quite a number of small reservoirs have been constructed, but they serve the purpose rather of storing the summer supply, during nights, Sundays, and other times when not in use in the irrigating season, than of holding back the winter supply for summer use. On the headwaters of the streams there are few of the broad, level valleys, covering hundreds of acres,

and having narrow outlets through high cañon walls, which characterize many of the rivers of northern California, and furnish natural sites for the storage of large quantities of water at minimum cost. The reservoirs for the southern section of the State must necessarily be smaller and more numerous, but the sites for such reservoirs are abundant, generally affording favorable conditions for cheap construction.

Los Angeles City reservoirs.

The City of Los Angeles has built two storage reservoirs, one of which, located in East Los Angeles, has a capacity of about 16,000,000 cubic feet, the other in the western portion of the town covers an area of 66 acres, and has a capacity of about 78,000,000 cubic feet. Into these reservoirs run the two high service canals, supplying the hill lands and more elevated portions of the city. Their exact cost could not be ascertained. The smaller one is said to have cost about $18,000, or $1 12½ per 1,000 cubic feet of storage capacity. The same is about 600 feet long, with a height of 20 to 25 feet in center, and a base of 180 feet in width. It consists of an earth embankment formed of the material at hand—a compact argillaceous soil—and puddled during its construction with three parallel streams of water running across it. It is severely criticized by engineers who witnessed its construction, and it has already exhibited signs of weakness. The other reservoir is also faulty, and gave way last spring at the point where the brick arch of the outlet sluice joined the shale rock through which the tunnel passes. The damage done was comparatively slight beyond that of the loss of the water contained in the reservoir, and was repaired at a cost of $1,000. The embankment was uninjured and seems thoroughly secure.

Lake Vineyard reservoirs.

A more extensive system of small reservoirs have been constructed by the Lake Vineyard Association, under the direction of J. De Barth Shorb, than are to be seen elsewhere in that section of country. On the upper tract there are three reservoirs, holding 3,000,000, 21,000,000, and 3,000,000 gallons respectively, and on the lower tract there are two, each having a capacity of 3,000,000 gallons. The cost of the smaller reservoirs per 1,000 cubic feet of storage capacity was from $1 81 to $2 32. They are circular in form, and consist of a simple embankment of earth, excavated from the interior, without revetment or lining of any kind. The soil is particularly favorable for making watertight embankments, containing elements which seem to form a crustation of natural cement on the surface, hard and impenetrable.

On the Alhambra tract adjoining the "Alhambra Addition" there are two reservoirs, each having a capacity of 1,000,000 gallons. I was told that their excavation cost but $60 apiece, or less than 50 cents per 1,000 cubic feet of storage capacity.

There are many localities where this impermeable soil prevails and where small reservoirs may be constructed at minimum cost. But where the bed of a proposed reservoir is composed of gravelly or coarse sandy soil it becomes necessary to line it with a thick coating of clay, concrete, or some other impermeable lining. In some localities it may be practicable to sluice in puddling material with the water, packing it gradually by sheep or cattle.

Cost of small concrete reservoirs.

As an example of the cost of a small reservoir of concrete, may be cited that of Mr. Sainsevain, 12 miles northwest from San Bernardino, at the foot of the mountains. It is 64 feet in diameter, having an average depth of 5¾ feet and a capacity of 137,000 gallons. It cost $740, or $40 95 per 1,000 cubic feet of storage capacity. The lime, which is of excellent quality, was burned within a few rods of the reservoir.

A small reservoir in East Los Angeles, built in connection with the sub-irrigation system heretofore described, cost $400, or $46 per 1,000 cubic feet of storage capacity. It is 41 feet in diameter, and is built in cylindrical form, with a simple wall of "asbestine stone," and a floor coated with the same material.

A good recommendation.

In the report of General Alexander, Isaac W. Smith, and other consulting engineers on increasing the water supply of Los Angeles, before referred to, the following commendable suggestion is made: "It would be a great convenience if each farm of sufficient size could have its own reservoir, water could then be sold to its owner by the reservoir full, its capacity being known. Irrigation could then all be done by daylight, and water would always be on hand for use on the lands commanded by such reservoirs. It might then be to the interest of the irrigator not to use any more water than was actually required, and thus a great saving of water would result; the control and supervision of the water would be rendered easy, the accounts simplified, and the revenue from the sale of water greatly increased."

MEASUREMENT, DISTRIBUTION, AND SALE OF WATER.

The devices for the measurement or division of water from the various irrigation ditches of Los Angeles and San Bernardino Counties are numerous. In the majority of cases, no measurement of actual volume is attempted, but the water flowing in the channel, whatever its quantity may be, is either divided mechanically into a certain number of parts, or the whole stream, if a small one, is used in rotation for certain fixed periods. A comparison of the systems of measurement and the cost of water, where sold, is interesting.

Division of water in Los Angeles.

I have referred to the division of the waters of Los Angeles River, controlled by the city, into seventeen "irrigating heads." This division is effected by thin board partitions placed in flumes in the main ditches where the depth is uniform and the sides vertical, the water being separated by the thin edge of the partition and passing on either side. Where the water is to be divided into two equal parts, this method of division is as accurate as could be desired; but if the parts are unequal—if, for example, a ditch carrying ten heads is to be divided into ditches carrying say three and seven heads, respectively—it becomes a question as to the proper location of the partition to secure the proportional division. It is a well-known fact that even in a flume the velocity in the center is considerably greater than on the sides. Were the breadth of the flume divided into proportional parts of three and seven by the partition, the larger side would receive more than seven-tenths of the whole, as it would

embrace a section whose average velocity was greater than that of the smaller section. In case the water were to be divided into three parts, the discrepancy would be still greater, and the central section would receive more than its due and the others less. These errors have been fallen into in the division of water in Los Angeles, and lead to some inequality in the volume of the irrigating heads.

Price of water in Los Angeles.

The present prices for water, as fixed by the City Council, are as follows, per irrigating head: For one day, two dollars; for one-half day, one dollar and twenty-five cents; for one night, one dollar and fifty cents; for one hour, fifty cents. The length of the day and night have been frequently changed, but the divisions between them are now, I believe, sunrise and sunset.

Preferred privileges of residents inside city limits.

The irrigators inside the city limits have the preference in the use of water, and have the first right to purchase water up to the limit fixed by the Council, *i. e.*, one head for 2½ hours for each acre, once each month. No land may be irrigated oftener than once a month. Any surplus that may remain is sold to irrigators outside the city limits for double price.

Method of distribution and sale of water.

The manner in which the distribution of water is arranged is as follows:

On the 24th and 25th of each month irrigators must make application in writing at the office of the City Zanjero for the water he desires to purchase during the following month, stating the number of acres he owns, the zanja from which he irrigates, the number of days, half days, nights, or hours that he wants the water, together with the date that he would desire it. When all applications from citizens are in, the Zanjero makes up a schedule, arranging the allotment to each, as nearly in accordance with the dates mentioned in the application as possible, giving preference to the earliest applicants. On the 27th and 28th following, the irrigators again apply to the office for permits, which are made out in accordance with the schedule, signed by the Mayor and Zanjero, and delivered to the applicants on payment of the money. The Deputy Zanjeros are alone empowered to open the gates and turn the water to each irrigator, which they do at the times specified in the schedule and permits.

Purchase of surplus water by outside districts.

On the first day of the month following, if there be any surplus unsold, the Zanjero is at liberty to sell it to outside irrigators, reserving a little to provide for emergencies until the 6th, when if no citizen requires more, all is finally sold to the outsiders. The latter have regular organizations in districts, with officers duly elected, and a Zanjero who is empowered to purchase and distribute the water they may desire after having received notice of the amount each may need. It sometimes happens that after all these have been supplied there remains a surplus. In such case the water is allowed to run to waste, to be surreptiously picked up and used by an outsider, or the opportunity thus afforded is taken for cleaning the zanjas and making repairs.

Division of water in Anaheim—price, etc.

In Anaheim the irrigators are the sole stockholders in the irrigation canal, and the water is divided among them by regular rotation, on payment of a certain fixed price, which is adjusted to such rates as shall, at least partially, meet current expenses. No measurement of water is attempted, but the whole volume of the ditch when full is divided into two irrigating heads. In times of scarcity, when it is not advisable to divide the stream, all the water is used in one head and the period of rotation adjusted to the necessities of the case. The price is variable, but at the time of my visit it was 50 cents per head per hour during the day-time, and 25 cents per hour during the night-time.

Measurement and sale of water in Orange, Santa Ana, and Tustin.

In the settlements of Orange, Santa Ana, and Tustin, irrigated by the canal of the Santa Ana Valley Irrigation Company, the water is irrevocably attached to the land. No landowner can irrigate his land without first becoming a shareholder in the water company. The stock is issued at the rate of one share for each acre, and upon the face of the certificate of stock is inscribed a description of the particular tract or parcel of land to which it is attached. Nor can a stockholder transfer the water right belonging to one tract upon another. Should he desire to temporarily suspend irrigation upon one tract and irrigate another, he must purchase new stock for the new parcel of land. The irrigating head is 100 inches, measured under a nominal four-inch pressure, through an orifice 33⅓ inches long by three inches high, in a box placed at the head of the distributing ditch. For this quantity of water the price charged at the time of my visit was $2 50 per head per 24 hours, or $1 50 per day and $1 per night. In winter when water is plenty the price is usually $1 50 per 24 hours.

Methods practiced on the Azusa Canal.

On the Azusa Canal, in the Upper San Gabriel district, the cost of maintenance and supervision is borne by the irrigators in proportion to the quantity of water each may use, as the revenues from the sale of water are applied solely to that purpose; and the rates are adjusted to meet the annual expenses. Prior to the past season the rates were 75 cents per head during daytime, and one-half that price per night, but in order to raise funds to make a survey and start work on a new ditch designed to cover a greater area of territory, the price was raised by the Commissioners last spring to double the former rates. The volume of the irrigating head is from three to three and a half cubic feet per second, but the methods used for making the division are so crude that there is great variation in the quantity. Each irrigator may have water every ten days if he desires it, and if the water is to be had.

Apportionment of water on the Duarte Canal.

On the opposite side of the San Gabriel the water is apportioned among the irrigators according to the acreage under cultivation. Its distribution is attended to by a Zanjero, under the supervision of the Commissioners. The expenses are met by a direct tax upon the lands irrigated, and no water is sold.

Price of water, Los Nietos District.

In that portion of the lower San Gabriel district under the supervision of the Los Nietos Irrigation District Commissioners, the present price is 10 cents per hour per head, or $2 40 per 24 hours. The irrigating heads are exceedingly irregular in volume, no standard of measurement having been adopted. The rotation is made every twenty days if possible, so that no farmer may be deprived of water longer than that time. The apportionment is made at the rate of one head of water for 24 hours for each 40 acres at each rotation.

Price of water in Pasadena—method of measurement.

In the Pasadena settlement water is sold by the inch, and is measured through a notch in a board placed across the ditch below the hydrant from which it is discharged, the notch being ten inches wide by two and a half inches deep. The water flowing from the hydrant and filling the ditch to the top of the notch is called a head, for which the price charged is twenty-five cents for three hours' run. The module is an imperfect one, as the water does not have a free overfall on leaving the notch, and the discharge must vary with the slope of the ditch and its consequent velocity. Were the overfall free, and the water allowed to drop a short distance, the discharge of this module would be about 0.3 cubic feet per second, unless there should be considerable initial velocity from the hydrant, when it would be greater. Water is also sold in "domestic streams," delivered through one inch pipes, with which considerable irrigation is accomplished on small tracts. The charge is one dollar per month for about two hours' run daily, the time, however, being roughly graduated according to the distance from and elevation below the reservoir, on account of the varying pressure and discharge produced by these elements. The price of the water is regulated to meet the expenses. The works being owned by the community nothing further than that in the way of profit is desired.

Price of water in Lake Vineyard—the module adopted.

The present price for which water is sold to irrigators by the Lake Vineyard Association is 25 cents per head of 30 inches for three hours' flow, although in selling the lands, the association reserves the right, if necessary, to charge 10 cents per 1,000 gallons. The water is measured through an orifice 10 inches wide and 3 inches high, in the side of a square box surrounding the hydrants, the latter being opened sufficiently to fill the box to the top of the orifice, and the water flowing out freely without pressure. The theoretical discharge of the module is 0.345 cubic feet per second, or 3,726 cubic feet per three hours' run.

Measurement and sale of water at Riverside.

The only locality in San Bernardino County where water is measured and sold by volume, is in the settlement of Riverside. Here the water rights are vested exclusively in the Riverside Land and Irrigation Company, and the irrigators have neither voice nor control in the management and distribution of the water, and with few exceptions do not own stock in the company. The standard of measurement is the miners' inch, delivered from the primary ditches through small gates placed at the head of the distributing ditches. These little gates are placed in a flume 12 to 14 inches wide and a

foot deep. A foot or two below the gate the flume widens to 18 or 20 inches by a square offset, forming a receiving chamber, at the lower end of which a pressure bar four inches in depth, is placed across the box, at a height of 2½ inches from the floor. This space is filled by a sliding board beneath the pressure bar, which can be opened to any desired distance for measuring any quantity of water up to the full width of the opening. The receiving chamber is filled to the top of the pressure bar by raising the regulating gate leading from the primary ditch after adjusting the slide to any size of orifice desired, and the water issues under a constant pressure.

By opening the slide 10 inches, the quantity delivered is 25 miners' inches. There are about 250 of these measuring boxes, costing $4 to $5 apiece. Prior to January 1st, 1879, the price was 2½ cents per inch per 12 hours' run in daytime, and 1½ cent per inch per night. These rates having failed to yield sufficient revenue to pay expenses, the price was raised to 4 cents per inch per day, and 3 cents per inch per night, or 6 cents per 24 hours.

General observations.

In considering the various systems of distribution, measurement, and sale of water, collectively, the fact must impress an observer forcibly that where, from local causes, as the scarcity of water, expensive construction, difficulty of maintenance, etc., high prices are necessary, there the water is made to accomplish the highest duty. On the contrary, I am inclined to believe, although I have no positive data to establish the opinion, that in the localities where the price is lowest the least duty is derived from it. There are exceptions, however, which prevent the deduction of any rule establishing anything like a uniform ratio between price and duty. But there is sufficient evidence to show that the scarcity of water, or other causes which necessitate a high price, is a direct stimulus to irrigators to use it economically, and it would seem that no other incentive to that end is effectual, not even the knowledge acquired by experience, that excessive irrigation is injurious to the crops, reducing the quantity and deteriorating the quality of the yield.

It should be borne in mind that with two exceptions (Riverside and Lake Vineyard), the water is owned, controlled, and its price fixed directly by the irrigators, through their agents, the Water Commissioners, Directors, or whoever may be chosen by them in executive capacity, according to their particular form of organization, and the rates are regulated to cover the necessities incident to maintenance of works and general expenses. That they are lacking in uniformity but illustrates the varying circumstances attending each case. It cannot be expected that a uniform price and value can ever be attached to water, but they must be governed by the conditions peculiar to each locality.

CHAPTER V.

DRAINAGE—EFFECT OF IRRIGATION ON SOIL AND CLIMATE, AND ON VALUE OF LAND—COST AND YIELD OF ORCHARDS AND VINEYARDS—CONCLUSIONS.

One of the causes to which may be attributed the high degree of success attending the practice of irrigation in Los Angeles and San Bernardino Counties, doubtless lies in the fact that the natural drainage of the country is excellent. The soils of the irrigated districts are generally porous, and underlaid with gravel, through which the water filters away more or less rapidly, in cases where the substrata are impervious or the slope of the land is so great that water will not stand long on the surface.

Nature having done so much, it has been unnecessary to pay that careful attention to the drainage of irrigated lands which is so highly essential to the preservation of the health of the people and the fertility of the soil, in some other less favored localities. Every evil is said to have its compensation. If the soils of that section require frequent watering to maintain plant growth, they are not cursed with stagnant water on or beneath the surface, and irrigation may proceed without becoming injurious to the climate, whose salubrity is a subject of just pride to the people of that section.

Where artificial drainage is required.

That portion of the country where nature requires most assistance in draining away the surplus surface waters, is in the low-lying valley bordering the sea coast, where the slope of the ground is comparatively light, and the surface soil is underlaid at a depth of a few feet with an impermeable stratum of clay. In that class of lands, which embrace thousands of acres, moisture is always found, and crops can be raised independent of irrigation or rainfall. Water which has filtrated from streams at higher levels is here brought near the surface by the clay subsoil, and saturates the overlying earth. This section lies within the great artesian belt. The water from artesian wells is frequently allowed to run to waste, forming stagnant pools which are necessarily injurious both to soil and climate. A thorough system of drainage is here essential. An appreciation of this fact led to the insertion of a clause in the "Bush Act" passed by the Legislature in 1874 (a law providing for organization of Irrigation Districts in Los Angeles County), requiring owners of artesian wells to check their flow when the water was not used for irrigation.

EFFECT OF IRRIGATION.

Effect on soils.

The effect of irrigation upon the soil is not considered injurious when water is properly applied. On light soils it is necessary to use comparatively small streams; otherwise there is danger of washing out the organic matter and the soluble fertilizing elements, leaving only the coarse mineral constituents of the soil, and rendering it sterile and unproductive. The clear, pure water used for irrigation, coming, as it does, chiefly from springs and artesian wells, carries so little of the rich fertilizing sediment, which characterizes streams passing for long distances through an alluvial region, that it does not

restore the elements of plant-growth to the soil, and constantly enrich it as does irrigation in some other parts of the State, so that extra precaution must be taken so to use it that it may not still further rob the soil to which it is applied. It may be that a realization of this fact has led to the use of very small irrigating heads, which may be distributed over the land without having sufficient hydraulic force to wash out and transport the most valuable elements of the soil.

In winter, when the rains collect and wash down fine particles of soil from the hillsides and cultivated fields, the streams are muddy, and it is in this state that the water is most beneficial to the soil when used for irrigation. There are many other good reasons why winter irrigation is desirable and preferable, but this seems one of the best of them.

Effect on climate.

Malarial fevers are not general in the irrigated districts of Los Angeles and San Bernardino. The salubrity of the climate is, doubtless, due in great measure to the purifying action of the sea breezes, which blow in daily from the adjacent ocean. My observations were too general to be able at this time to draw any deductions as to the influence that irrigation may have toward producing the sickness that occurs in the irrigated districts. It is not claimed, at least, that irrigation improves the healthfulness of the climate where it is practiced.

VALUE OF LAND—IRRIGATED AND NON-IRRIGABLE.

No more forcible argument can be adduced in favor of irrigation than that presented by the comparative value of lands provided with facilities for irrigation, and those of a similar nature devoid of water privileges. This contrast is rendered the more striking on account of the high intrinsic value of the crops to which irrigated lands are devoted in the section described in the foregoing pages, and which in turn impart a higher value to the land on which they are produced. The orange and lemon, olive and vine, English walnut and fig yield much more revenue per acre than wheat, barley, corn, or potatoes. Prior to 1870 the land on which the thriving settlements of Orange, Santa Ana, and Tustin are located was a dry red gravelly plain, producing nothing but the usual growth of winter grasses common to all uplands in California, and affording grazing for stock for a few months each year. It was unsalable at $5 per acre. The construction of the irrigation canal which now waters the plain wrought an interesting change, converting it into a garden of orange orchards and vineyards. Unimproved land under the canal is worth $100 to $200 per acre, while that outside the canal, and unprovided with water, has no more value than before. Improved lands, planted to orange trees, sell for $350 an acre and upward.

A similar metamorphosis has been wrought in Anaheim. Before the improvements were begun there the land was a sandy waste, covered with cactus and sagebrush. Irrigation has made it what it is, one of the most fertile and beautiful garden spots of California.

Another striking example is to be found at Riverside, where the land above the irrigating canals is not worth $2 50 per acre, while that below them sells for $35 to $50 an acre, wholly unimproved, the quality of the soil being identically the same. Improved lands have no stated market value, as there are few sales, the improvements

being made by settlers who are making for themselves permanent homes and do not care to sell, but they are doubtless worth quite as much as lands devoted to the same products in other localities.

These examples could be indefinitely multiplied, as illustrating the beneficial results of irrigation in adding to the general wealth of the country, but those cited are sufficiently striking to suffice. In contemplating these results, one need not wonder that water for irrigation should be so eagerly sought for, and its possession and use defended as earnestly as more tangible wealth. It is the vital element upon which the wealth of the country depends.

COST OF ORANGE ORCHARDS AND VINEYARDS, YIELD, ETC.

The cost of the leading products of Los Angeles and San Bernardino Counties, or those for which they are most noted abroad, may be interesting in connection with this subject. The following estimate of the cost of vineyards per acre in Anaheim, is furnished by Theodore Reiser, President of the Anaheim Water Company:

First Year.	
Plowing, twice, before planting, per acre	$4 00
Harrowing, per acre	1 00
Cuttings for 1,000 vines, per acre	5 00
Planting, per acre	3 00
Plowing, preparatory to irrigation, per acre	2 00
First irrigation, water and labor, per acre	2 00
Third and fourth plowing, per acre	4 00
Second and third irrigation, water and labor, per acre	4 00
Stakes for vines, first cost, per acre	8 00
Pointing and sticking stakes, and tying vines, per acre	5 00
Total at end of first year	$38 00
Second Year.	
Trimming, per acre	$2 00
Plowing, twice, per acre	4 00
Irrigating twice, water, and labor per acre	4 00
Cultivating four times per acre	8 00
Total cost for second year	$18 00
Third Year.	
Trimming, per acre	$3 00
Irrigation and cultivation, per acre	16 00
Tying, staking, and suckering, per acre	6 00
Total for third year	$25 00

The total cost at end of the third year, when the yield begins to pay expenses, is thus $81 per acre.

The fourth year the yield would be about 6,000 pounds per acre, producing about 350 gallons of wine, worth when new 20 to 30 cents per gallon. The average proportion between grapes and wine is about 17 pounds per gallon. In subsequent years the yield would continue to increase to about 1,000 gallons per acre. An acre of vineyard is considered worth $250. In Riverside, where the raisin grape is almost exclusively grown, the net profits per acre, as represented, are temptingly large.

J. De Barth Shorb, an experienced horticulturist of San Gabriel Valley, makes the following estimate of the cost of an orange orchard:

First Year.

First cost of land, per acre	$75 00
Plowing and harrowing, per acre	3 00
Laying out land in squares, per acre	50
Digging holes, 60 per acre	2 50
Trees, seedlings, three years old, at fifty cents each	30 00
Planting	2 50
Two plowings	3 00
Irrigation and subsequent cultivation	10 00
Interest on investment	15 12
Total cost at end of first year	$141 62

Second Year.

Irrigation and cultivating, trimming, etc.	$20 00
Protection of trees from gophers, etc.	10 00
Interest on investment	20 52
Total cost at end of second year	$192 14

Third Year.

Cultivation, pruning, irrigation, etc.	$40 00
Taxes for three years	5 25
Interest on investment	28 44
Total cost at end of third year	$265 83

Fourth Year.

Cultivation, pruning, irrigation, etc.	$50 00
Taxes	3 00
Interest on investment	38 16
Total cost at end of fourth year	$356 99

Fifth Year.

Cultivation, etc.	$50 00
Taxes	3 00
Interest	49 08
Total cost at end of fifth year	$459 07

Sixth Year.

Cultivation, etc.	$60 00
Taxes	5 00
Interest	62 88
Total cost at end of sixth year	$586 95

Seventh Year.

Cultivation, etc.	$60 00
Taxes	5 00
Interest	78 12
Total cost at end of seventh year	$720 07

At this age, the trees being ten years old from the seed, should bear 250 oranges apiece, yielding a net revenue of $46 per acre, after deducting expenses and interest on the entire investment. This estimate is based upon hiring all the work done, upon a small scale—for orchards of say five or ten acres. On a large scale it can be reduced 25 per cent, and when the owner does the work himself, 35@50 per cent. It includes compound interest at 12 per cent. per annum.

Other horticulturists estimate the first cost of an orchard, not including value of land or interest on investment, at $45 to $50 for the first year. In Riverside orchards are planted and cared for on contract at $15 to $20 per acre, not including cost of trees or water. Budded trees begin to bear at three years old, and are expected to pay expenses at five or six years old. At fifteen years, either budded

or seedling trees should bear 1,000 to 1,500 oranges each. The market price ranges from $15 to $50 per thousand, according to size and quality.

To show the large proportion which the citrus fruits and vineyards (the most valuable products of California grown by irrigation) bear to the whole area of irrigated land, accurate statistics would be of the greatest interest. The statistics given in the biennial report of the Surveyor General do not give an adequate idea of the extent of this character of culture, as no account is taken of the thousands of acres of young orchards and vineyards which have not yet come into bearing. Roughly estimated, there are in Los Angeles and San Bernardino Counties about 11,000 acres devoted to orange, lemon, and lime trees, principally the former; and about 15,000 acres in vineyards. Enumerated individually the trees of the citrus family number 750,000 to 800,000, and the vines about 15,000,000.

A careful enumeration of the trees and vines of Riverside was made last year, with the following result: Orange trees, 160,861; lemon trees, 23,550; lime trees, 28,642; olive trees, 3,531; apricot trees, 13,192; deciduous fruits, 30,677; vines, mostly raisin grapes, 221,465. These cover an area of about 4,000 acres.

In the vicinity of San Gabriel Mission there were in 1877, 1,300 acres of orange orchard and 942½ acres of vineyard. Of the oranges, but 5,752 trees were bearing that year, the total value of the crop being $47,683 32; an average of $529 81 per acre. A considerably greater area is now devoted to that fruit. One orchard over 15 years old produced an average of 1,215 oranges per tree, the crop selling at the rate of $1,000 per acre. The vines yielded 7,540,000 pounds of grapes, from which 264,667 gallons of wine, and 44,933 gallons of brandy were made, the total value of crop being $222,199 50; yielding a net revenue of $70,906 70, or about $75 per acre.

These statistics, which are vouched for by reliable citizens as accurate, present the value of irrigation in a clearer light than any general argument can possibly present it, and tend to a conviction of the necessity of fostering and promoting a comprehensive system of irrigation by which such results may be more generally achieved.

CONCLUSION.

In this report I have endeavored from the knowledge in my possession to present a general idea of the extent, character, and importance of irrigation in the Counties of Los Angeles and San Bernardino. A more careful and detailed investigation than it was possible for this Department to devote to that interesting section, would possibly change, in many respects, the impressions therein outlined, and modify and amplify the statements given, but with the data of which we are possessed, I think the following conclusions may be drawn with safety:

First—That while the area of land irrigated may be considerably extended with the water now available, the water supply, widely diffused as it is over the country, is inadequate to the irrigation of all the lands which may be classed as cultivable and requiring irrigation, or irrigable lands. That with a well planned and properly constructed system of reservoirs, and a thorough development of the water sources afforded by the numerous cienegas, a sufficient supply

may be made available for the irrigation of all, or a large proportion of the lands which may be considered profitable to irrigate.

Second—That while a large proportion of the water is now wasted by inefficient and badly constructed ditches, many of the works have been projected with intelligence and skill, effecting the utmost economy in securing the water.

Third—That there is much room for improvement.

Fourth—That with the water actually applied to the lands, owing to the nature of the crops irrigated, a higher average duty is accomplished than has yet been attainable in general agricultural operations in the San Joaquin Valley.

Fifth—That the highest duty of water is only attained where its scarcity compels the utmost economy in its use.

Sixth—That the most valuable crops, yielding the highest net revenue per acre, and adding most to the general wealth of the country, require less water than the ordinary farm products, and justify the expenditure of larger sums in the construction of works for developing and economizing water.

Seventh—That, generally speaking, the art of irrigation has reached a higher state of advancement in the special branches peculiar to that section, than in any other portion of the State which I have been detailed to examine. This is due to the fact that irrigation is no longer an experiment, but has been practiced for many years. The laboring population have become skilled in the use of water, and have, to a great extent, acquired that experience and knowledge of the special requirements of the soil, the best methods for preparing it, and the proper ways of applying water which are so essential to success in irrigation.

I have not considered it my duty, and with my comparatively limited knowledge of all the conditions pertaining to the subject, I am unprepared to suggest efficient measures for the advancement of irrigation in that section. The private rights which have been acquired would doubtless interfere with any comprehensive system of regulation and equitable distribution of water, by competent authority; but if by some means these rights could be thoroughly defined and settled; if the volume of water to which all parties are entitled could be definitely ascertained; if the right to water could be made dependent upon its economical use; if the obstacles which now prevent the owners of dry lands from entering upon and developing the waters which now run to waste, by the construction of the proper works, could be removed, irrigation could be more rapidly and more widely extended, and its general interests highly promoted. That this end can be attained, or that its attainment is practicable, without too seriously interfering with private rights, I am unprepared to assert.

My investigations were greatly aided by the many courtesies received from members of my own profession, and many other intelligent and agreeable gentlemen, to whom I am indebted for much of the information conveyed in these pages. It gives me pleasure in closing to acknowledge these courtesies.

Respectfully submitted.

JAS. D. SCHUYLER,
Assistant Engineer.

[APPENDIX B.]

REPORT ON THE WORKS AND PRACTICE

OF

IRRIGATION IN KERN COUNTY.

JAS. D. SCHUYLER, ASSISTANT ENGINEER.

OFFICE OF STATE ENGINEER,
SACRAMENTO, CALIFORNIA, January 1st, 1880.

William Hammond Hall, State Engineer:

SIR: The gauging surveys and current observations of Kern River, and the irrigation canals leading therefrom, were begun under my charge, January 1st, 1879, and continued through the months of January and February. Gauge rods were erected at various points in the river and in each of the canals, a daily record of which was kept by a special observer assigned to that duty throughout the entire season of irrigation.

In June and July a second series of gaugings were made, together with special observations on various points bearing on the subject of the inquiry—the study of the irrigation problem as developed in that section.

The results of this work are given in the following pages, in which I have endeavored to present as clearly as possible an intelligent review of the whole field of irrigation, a description of the methods employed, the results attained, and the circumstances attending the use of water in agriculture, drawing the conclusions and deductions which seemed justified by the facts in our possession.

WATER SUPPLY.

The first and most important consideration in a section where agricultural success is wholly dependent upon irrigation, as in Kern County, is that of the water supply, for upon its permanence and volume depend the wealth and prosperity of the community. Fortunately Kern River, which is the sole source of supply for all that portion of the San Joaquin Valley south of Tulare Lake, is an unnavigable stream of large volume, whose waters can be entirely diverted without injury to any public interest, and whose discharge, though variable, is unfailing. The river heads among the loftiest

peaks of the Sierra Nevada, whose ice fields and beds of snow only yield to the heat of midsummer, furnishing a great volume of water long after the winter rains on the lower mountains have drained away. The rains of winter and the melting snows of summer thus maintain the full flow of the stream through the first seven months of the year, the season of greatest demand.

In some seasons the maximum discharge occurs sometime during the first three months of the year; in others, the months of May, June, or July will witness the greatest flood; but ordinarily there are two periods of extreme flow each year—the rain-flood of winter and the snow-water flood of summer.

The season of lowest water occurs in October, after which the stream begins to increase in volume, as evaporation lessens, until the first rains come.

The following table shows the maximum, minimum, and total discharge of the river at Rio Bravo Rancho, mouth of cañon, for each month during the year 1879:

Kern River—Table of discharge.

1879.	Maximum discharge in cubic feet per second.	Minimum discharge in cubic feet per second.	Total discharge in cubic feet for the year.
January	686.8	389.1	1,237,551,000
February	745	466	1,428,796,800
March	659	510	1,478,649,600
April	1,054	661	1,979,337,600
May	1,231	680	2,482,272,000
June	1,190	812	2,517,955,200
July	865	386	1,433,116,800
August	387	168	713,404,800
September	174	146	442,540,800
October	174	152	436,233,600
November	242	152	477,964,800
December	511	174	670,636,800
Total for the season			15,298,459,800

Monthly average	1,274,871,650
Average per second	485.1
Area of mountain watershed, in square miles	2,382
Discharge in cubic feet per second, per square mile of drainage area	0.2
Average depth drained off, in feet	0.23

These estimates of discharge were based on a series of observations made at different stages of high and low water, together with the daily rod-readings taken throughout the whole period.

From one high watermark pointed out as that left by the flood of 1867–68, the discharge was estimated at 29,000 to 30,000 cubic feet per second, and from similar marks the maximum flood discharge of 1877–78 was calculated to be 4,800 cubic feet per second. In May, 1873, the United States Commissioners on irrigation estimated the discharge of Kern River at 3,000 cubic feet per second.

Although I have not sufficient data to calculate the mean flow for a number of years, it is probable that with the exception of the dry years of 1864 and 1877, the past season of 1879 was one of extreme low water in Kern River, and that in ordinary years, say four out of five,

the mean discharge during the irrigating season does not fall far below 2,500 to 3,000 cubic feet per second.

Physical features of Kern River.

From the longest fork of the river to the mouth of the cañon, the distance is about 115 miles, in which it falls 10,000 to 12,000 feet, in a series of cascades, through wild, rocky cañons, alternating with short, level reaches in park-like valleys. From the point where it leaves the mountains it flows for 18 miles between high, gravelly bluffs, entering the plains a short distance above the Southern Pacific Railroad bridge, the latter 14 miles having an average slope of eight feet per mile. It follows a southwesterly course from the railroad bridge toward Buena Vista Lake, flowing in a shallow bed of coarse sand, 300 to 800 feet wide, with an average inclination of six feet per mile, to Buena Vista Slough, where its waters part, a portion flowing south, into Buena Vista Lake, when unobstructed, and the remainder seeking an outlet northward, in Tulare Lake, through 50 miles of swamp land.

The discharge into Buena Vista and Kern Lakes (which lie at the same level, connected by a slough), ceases when they have been filled to the elevation of the river's mouth, and all the water flows toward Tulare Lake.

The elevation of the river at the railroad bridge is 408 feet above the mean tide datum plane established by this Department, while the two Lakes, Kern and Buena Vista, which occupy the lowest and southernmost portion of the valley, have an elevation, when full, of about 290 feet.

The area of Kern Lake at an elevation of about 287 or 288 feet, is 8,298 acres; and of Buena Vista Lake, 16,130 acres. Their present elevation is 282 to 284 feet, and their area one-fourth to one-third that given in the above figures. They are shallow, and fringed with a border of swamp lands, and are almost unapproachable on the south and west, on account of the deep, slimy ooze composing their banks and bottom. Their present maximum depth is six to ten feet. The slough connecting them is deep and tortuous, 100 to 150 feet wide, and 12 to 13 miles long, with firm banks of tule sod three to five feet high. The lakes occupying the lowest part of the valley naturally receive the drainage of the irrigated lands of Kern Island, which furnishes a partial equivalent to the great loss resulting from evaporation. They have a natural high-water outlet through Buena Vista Slough toward Tulare Lake, but this outlet has recently been cut off by a levee thrown across the head of Buena Vista Lake, preventing the river from discharging into it, or any water escaping therefrom.

In times past Kern River has spread at will over its fan-shaped delta, discharging its waters into the lakes through numerous channels. These channels have been repeatedly filled by sand and silt brought down from the mountains, new ones have been formed, and the operation repeated until the delta assumed its present diversified topographical features, intersected by blind sloughs fringed with willows, and ridges of sand, alternating with stretches of fine alluvion.

IRRIGATION DISTRICTS.

The land irrigable from Kern River may be described as naturally divided into six districts, as follows:

First—The district lying between "Old South Fork," the easternmost of the former channels of Kern River, Kern Lake, and what is termed "Old River," comprising 80,000 acres (of which 32,000 acres is swamp land, almost wholly reclaimed), supplied with water for irrigation by the Kern Island, the Old South Fork, the Farmers, the Stine, and the Castro Canals.

Second—The district bounded by Old River, Buena Vista Lake and Slough, and the present channel of Kern River, comprising about 64,000 acres (of which 10,000 acres is unreclaimed swamp land), watered by the Buena Vista, James, and other minor canals and ditches. These two districts comprise Kern Island, with a total area of 144,000 acres, and within their boundaries are the major portion of the lands at present irrigated and cultivated in Kern County.

Third—The district north of Kern River, south and west of Goose Lake Slough, and east of the line of swamp and overflowed lands, watered by the Pioneer, Johnson, James & Dixon, Dixon & Joice, Wible, Goose Lake, Railroad, and other lesser canals, comprising 70,000 acres.

Fourth—The district known as Swamp Land District 121 (or that portion of it lying north of the mouth of Kern River, comprising about 43,000 acres), and Swamp Land Districts 184, 185, and 208, containing 59,768 acres, an aggregate area of nearly 103,000 acres, irrigable in part by means of the Kern Valley Water Company's canals, partially completed.

Fifth—The district bounded on the east of the highest practicable grade line for a canal on the north side of Kern River (which may be taken as the grade line of the Beardsley Canal, extended northward to the county line), and bounded on the west by Goose Lake Slough and the line of swamp lands, and south by Goose Lake Slough and Kern River. The total area of this great district is about 360,000 acres, of which about 60,000 acres is above the grade line of the Calloway Canal. That portion of the district near the river is commanded by the Beardsley, McCord, McCaffrey, Emery, and Jones & Tuckey Ditches, while the Calloway extends northward nearly over its whole length.

Sixth—The lands lying east of Kern Island, and bounded north, east, and south by the foothills and mountains, properly form a distinct district, a portion of which may be covered by a projected branch of the Kern Island canal, and all of the district would be commanded by a projected canal from the mouth of Kern River Cañon. There are about three townships, or nearly 70,000 acres of arable land in this district.

The whole area of land that may be covered by completed or projected works for irrigation from Kern River, therefore, foots up 747,000 acres. Of this area, about one third cannot be considered "irrigable," as it is not and probably cannot be made susceptible of profitable cultivation, leaving but about 475,000 acres of irrigable land, of which about eight per cent has been irrigated.

DESCRIPTION OF SOILS.

The results attained by irrigation, the quantity of water required, and the cost of its application, depends in so great a degree upon the nature of the soil, the depth and character of the subsoil, and the consequent effect produced by artificial irrigation, as well as upon the slope and topographical features of the surface, that a general description of soil characteristics in the several districts named is necessary to a correct understanding of the conditions. In a country whose surface is generally flat, any unevenness in contour is not noticeable in ordinary farming operations, but where water is to be applied for irrigation, irregularities that may scarcely be detected by the eye become of importance, and must be studiously regarded in laying out a farm, in order to secure most perfect success. An absolutely uniform plane, gently inclining, presents the most perfect conditions for irrigation, but this character of land is rarely met with.

District No. 1, on Kern Isla d, has a pretty uniform slope of seven feet per mile from the river to Kern Lake, but the surface is quite uneven, and diversified by low rolling sand ridges and shallow troughs, the remnants of sloughs that are now dry, but ramify through the land in winding courses toward the lake, and are used either for distributing channels or for drainage, with occasional long stretches of smooth-surfaced, black loam, upon which are generally found dense thickets of willows and cottonwood trees.

As the ridges, or higher portions of the ground, are generally continuous for long distances, they are selected for the location of the canals and distributing ditches. The distributing system cannot, therefore, be laid out with any regularity or conformity to rigid straight lines, but otherwise the land is favorable for economical irrigation. To disregard even the very gentle irregularities of surface, and construct ditches upon straight lines, would be to fail in the object desired—the uniform wetting of the soil—as higher spots would get no water, and the low ground receive too much.

The quality of the soil in District No. 1 varies so greatly that one description would scarcely apply to the whole of any one square mile. The digging of wells may at one place reveal successive strata of sand and loam, a foot or two in thickness, with occasional streaks of clay, and a short distance away another well may show something entirely different; the loam may be continuous for eight, ten, or fifteen feet in depth, underlaid with sand, and vice versa.

In general, the soil of the district is very fertile, easily worked, cheaply irrigated, and contains little land that may not be profitably cultivated.

More than one-third of the district is reclaimed swamp land, which is now the most desirable of any in the district, the decaying vegetation in the soil serving to enrich the land, and the tube-like roots of former swamp growth facilitating the rapid percolation of water applied for irrigation. This character of soil is easiest irrigated, and retains moisture longest, but irrigation is quite as necessary to the growth of crops upon it as upon any of the lands of the valley, notwithstanding its swampy character prior to reclamation.

In this district, 22,750 acres are now under irrigation.

District No. 2, comprising the western portion of Kern Island, is

less desirable as agricultural land than the eastern portion just described. At the upper end of the district the soil is sandy and porous, with no impervious substrata nearer than 15 to 20 feet below the surface.

Adjacent to Old River, and along the course of a slough passing down the center of the district, the soil is more loamy in character, with clay within six to ten feet of the surface, merging into black adobe in the lower portion adjacent to the lakes.

The loam is generally overgrown with salt grass, a certain indication of the presence of alkali in the soil. It is difficult to bring under cultivation on account of the toughness of the sod, but it proves to be very fertile when properly worked, and the alkali does not appear to injure its quality, but rather to facilitate the retention of moisture.

When flooded it becomes very soft, and in a few days, with hot weather, a thin crust or film forms on top, which appears to arrest rapid evaporation, while the clay subsoil prevents the water from soaking away too quickly, as is the case where the surface soil is underlaid with sand. This class of land was for years avoided and considered worthless, but latterly it is better esteemed.

There are ridges of coarse sand running through the district, between the watercourses, which are in places too irregular for profitable irrigation.

In the vicinity of Buena Vista Lake the land has the appearance of being very fertile. It is very uniform in surface and slope, but is underlaid with a deposit of alkali, which with irrigation is brought to the surface as a thick white efflorescence, destroying vegetation. With good drainage and skillful application of water the alkali may ultimately be washed out. An experiment on an extensive scale, made a few years ago by Haggin, Tevis & Carr, proved a failure, after an expenditure of some $20,000 in ditching, preparation of land, etc., and it is possible that the soil is irreclaimable at reasonable cost.

Nowhere else in Kern County, except in isolated small spots, has alkali proved a serious detriment to the soil under irrigation, but it is, on the contrary, claimed to enhance the fertility of sandy soils.

In District No. 2, 7,620 acres, or 12 per cent. of the whole area, are irrigated and cultivated.

District No. 3, north of Kern River, is composed, to a considerable degree, of coarse sand, of such depth as to absorb great quantities of water, when under irrigation. The lower portion of the district is a compact loam, several feet in depth, underlaid with clay, and requiring the minimum amount of moisture to produce crops. The two extremes of greatest and least absorptiveness meet here side by side. Between Goose Lake Slough and the swamp lands lying to the west is a belt of alkali land, some twenty miles long and two to three miles wide, which is comparatively valueless. Of the whole area in the district, 5,000 acres, or about seven per cent., have been irrigated, but were not all irrigated in 1879.

District No. 4 consists wholly of reclaimed swamp lands between Buena Vista and Tulare Lakes. The land is remarkably smooth on the surface and uniform in character. The soil appears to be of prime quality, but as the high land on each side and sloping toward it is composed of alkali, investigation may prove that the same formation extends underneath the vegetable loam of the swamp land. So little of this land has yet been cultivated on account of a lack of water since its reclamation, that it is impossible to judge of its true

character and capacity. On the border of this swamp the well water is brackish, salty, and unfit to drink, while in the interior it is said to be pure and sweet.

District No. 5.—The leading characteristics of soil in this district are coarse gray sand and sandy loam, composing the plains north of Kern River, and shading off into alkali soil on the western portion of the district, bordering the swamp lands. The sand is principally confined to a few square miles near the river, and merges into brown sandy loam of a uniform appearance, extending as far north as the county line.

The soil of the plains is radically different from that of the river-made lands of Kern Island. It is rich in mineral substance, but contains no vegetable or alluvial matter. It is as dry as possible for 40 feet or more in depth, appearing to have never been thoroughly wet. After an ordinary rainy season the plains are covered with a scanty growth of alfilerilla, a very nutritious, succulent grass, common to all California valleys. Sagebrush appears here and there, on the better grades of soil.

The subsoil consists of a stratum of yellow hardpan of cemented sand, two or more feet in thickness, and lying at depths of from one to twenty feet below the surface. It is plowed with difficulty, but crumbles when exposed to the action of the air and water. It is not therefore wholly impervious, but where it lies at a depth of four to six feet below the surface it is of great advantage in checking the downward infiltration of water applied in irrigation, and aids the soil in retaining the moisture thus applied.

The soil of the plains is honey-combed with the holes of rats, gophers, badgers, and other vermin, and on the first application of water absorbs it rapidly and in great quantities, becoming very soft. It settles immediately, and on the second application absorbs much less water, and will sometimes bear the weight of a man or a horse, even while the water is standing upon it.

Of this district 4,570 acres, or about one and one-fourth per cent. of the whole, has been irrigated.

The general slope of the plains west of the railroad, is from ten to twenty feet per mile, while east of the railroad, approaching the foothills, the slope is much greater. The grade line marking the eastern boundary of District 5 is, as has been said, the highest one practicable for a canal, on account of the great cost which would be incurred in cutting a canal on a higher grade along the face of the bluffs near the river. There is, however, a strip of excellent arable land along the foothills north of Kern River, and extending to the county line, which may ultimately be made available for agricultural purposes by a system of storage reservoirs in the foothills, fed by the flood-waters of Posa Creek and other intermittent streams.

District No. 6.—A considerable portion of the irrigable land in this district is a mellow alluvial loam, consisting of the finer sediment deposited by the flood-waters of Caliente Creek. The western portion, adjacent to Kern Island, is strongly alkaline. The land is generally uniform and smooth upon the surface, but inclining westward, with a slope as great as 100 feet per mile near the base of the mountains, flattening gradually to about 20 feet per mile near the western limits of the district. It is favorably formed for irrigation, and the richness of the soil is indicated by the heavy growth of sunflowers and other weeds that spring up wherever the surface is overflowed

by the winter floods of Caliente Creek; but this moisture is not retained by the soil a sufficient length of time to mature crops.

DIVERSION OF WATER.

As heretofore mentioned, Kern River has a slope through the valley of from six to eight feet per mile, and lies in a shallow sandy bed, with banks of sandy soil three to six feet high. These favorable conditions enable water to be taken from it at almost any point with a minimum of cost. No permanent dams or expensive headworks are necessary; a simple wingdam of sand and brush, running out into the channel at an acute angle up the stream, serves every purpose of diverting water into the canals. These wingdams are liable to be swept away with every freshet, but as they are inexpensive, no serious loss is entailed. [But one dam—that of the Kern Island Canal—was ever constructed across the river, and this has been finally abandoned, on account of the heavy cost of maintaining it in repair. It was built of brush mattresses, staked and weighted down with gravel. It cost, originally, $7,000, and subsequent repairs for three years cost nearly $12,000. It rested upon a bed of quicksand, which was constantly being undermined, and every freshet rent a hole through the body of the dam. When the dam was abandoned, the canal was simply extended about half a mile further up stream, and a wingdam of sand thrown out, diverting all the water required. Two weirs thrown across the river to control the water—one at the head of the James Canal, the other at the county bridge, below the Pioneer—have failed of their object, and been damaged by floods.]

The ease with which water can be diverted from Kern River, accounts for the great number of canals and ditches which have been taken from it at all points, there being no less than thirty-two, large and small. It would be better if there were fewer, as the division of water into so many channels gives rise to a great loss in the river in reaching the lower ones—a much greater loss than would occur if all the water were diverted into two main canals, where it emerges from the foothills, with regularly laid out distributaries running therefrom to all the irrigated lands.

Headworks, character of.

It is found necessary to construct substantial headworks in the canals to control the admission of the water. They are made entirely of wood, there being no stone available in the vicinity; the object always is to reduce the first cost to the least possible figure. The better class of these are constructed upon a foundation of anchor piles driven as far as possible into the sand, with sheet-piling of 2-inch planks at the upper and lower sides of the structure. After the foundation the next requisite to stability is the wings, which extend 15 to 20 feet on either side into the banks, well protected with sheet piling. They are sometimes made flaring, but experience seems to show that when they are placed at right angles to the canal the water has less action upon the banks.

They are not arranged with gates, which are considered too cumbrous and inconvenient to handle, but in their stead are placed loose planks, six to eight inches wide, running in grooves, the length of the structure being divided into bays of convenient length (usually about 4 feet), with posts that are placed either vertically or inclining back-

wards at an angle of about 45°. The weir boards rest against the posts, and the water is admitted either as an overfall above the boards, or under pressure through an aperture left open beneath. The former method is preferred, as it takes the water from the top of the stream, and less sand is thereby carried into the canal. The cost of these structures varies from about $200 for small ditches, to $3,000 or $4,000 for the larger canals. The best structure of that kind is that built in January, 1879, for the Kern Island Canal. It cost $4,000, and is provided with a waste sluice for scouring the sand from in front of the gate. The bays incline down stream at an angle of about 45°, and it draws water from the top, the height of the overfall being regulated according to the stage of water in the river and the quantity desired in the canal.

The slope of the irrigable land is so great that there is no difficulty in running canals in any direction over it, nor in distributing the water in the smaller ditches, or in draining it off. It is therefore peculiarly favorable for irrigation; but the soil is too friable to permit of canals of any size taking the natural slope of the ground without serious erosion and damage.

Grade of canals regulated at will by weirs or drops.

The grade is therefore regulated by "drops" or weirs placed at necessary intervals (usually half a mile to one mile), with movable weir-boards which are also convenient and necessary for raising the water high enough to enter the distributing ditches. These drops are constructed similar to the canal headworks, and are characterized by an absence of ponderous gates for regulating the water, and extreme lightness of timber used, the greatest economy of material having been studied. They require to have substantial foundations and wings, and must be put in place with skill to secure their permanency. It is true they add considerably to the expense of the canal, but this is probably offset by the saving in length of distributing ditches, which, without the means of raising the water level in the main canal, would need to be taken out considerably higher up.

Side slopes in various soils.

The side slopes on canals are usually made one on three, sometimes greater, sometimes less, according to the character of the soil. Sandy loam takes a natural slope of about one on three, but if it is filled with roots of trees will stand nearly vertical. Soil on which wire grass and salt grass grows will admit of slopes as steep as one on one, without washing or caving in; coarse sand requires the flattest slopes of all, and is given from four on one to six on one.

Sand flow.

The mountains drained by Kern River are composed of friable granite, which is rapidly disintegrating. The river, therefore, transports a great quantity of sand. The volume of the stream in its course through the valley being constantly diminished by the irrigating canals, and its flow being checked by the wingdams to some extent, its transporting power on the valley portion of its course is decreased, and the sand is dropped in its bed all along through the valley. The natural result is that since the beginning of irrigation the bed is slowly rising, diminishing the capacity of the channel and increasing the liability to overflow. With the gradual filling of the

bed, the difficulty of keeping sand out of the canals is increased. It is found that for a distance of a mile or more from the river the canals receive a yearly deposit of sand, six inches to a foot in depth, which must be cleared out regularly to maintain the capacity of the channels. Prior to the commencement of general irrigation, the current of the stream was unchecked, and the floods swept the sand to the river's mouth and into the lakes. The effect of this accumulation of sand may ultimately be to compel the diversion of water for irrigation through a few large canals, the abandonment of the rest at the head, and the construction of levees on either side of the river as a protection against overflow.

CAPACITY OF CANALS.

The total maximum capacity of all the irrigation canals taken from Kern River is about 3,900 cubic feet per second. In the event of an ordinary flood they would therefore diminish the volume of the stream very materially, as the high water of 1877–78 probably did not exceed a discharge of 4,800 cubic feet per second, and the season was one of more than average rainfall. But should a flood similar to that of 1867–68, with a discharge estimated approximately at 29,000 cubic feet per second, occur, it must result disastrously to many of the canals, and overflow much of the country. Presuming that they remained in good condition, with their carrying capacity unimpaired, after they had taken all they were capable of, there would remain over 25,000 cubic feet per second to pass down the river. The channel is incapable of carrying that quantity, and general overflow would naturally ensue. Old River could carry possibly 500 to 600 cubic feet per second, and the remainder would ultimately find its way into the lakes, a portion passing over the levee at the head of Buena Vista Lake, and a portion seeking its natural outlet toward Tulare Lake, through the Kern Valley Water Company's canals. As these have an extreme capacity of but 3,370 cubic feet per second, it is improbable that they could carry what water would seek to pass through if the river retained its maximum stage for any length of time. These floods are fortunately of rare occurrence, but two having occurred since the settlement of the country by Americans—those of 1862 and 1868. They are said to have been of short duration, and the greatest flood wave to have been occasioned by land-slides in the mountains temporarily damming the water, and then giving way with an overwhelming torrent. The flood of '62 left large pine logs, some of which were six feet in diameter, scattered over Kern Island. It is stated by early settlers that no pine driftwood was to be seen in the valley prior to the '62 flood.

DESCRIPTION OF IRRIGATION WORKS.

Having outlined in the foregoing, the general characteristics of Kern river and the lands irrigated and irrigable therefrom, I now pass to a consideration of the irrigation works already constructed, and shall describe them briefly in the order of the natural districts before referred to.

District No. 1.

As late as the year 1870 no lands were irrigated in Kern Valley outside of the limits of this district, and even at the present time

more than one-half of all the lands irrigated in the valley are within its boundaries. The Town of Bakersfield and a majority of the farming population of the valley are included in the section described as District No. 1. In 1867 the settlers in the delta of Kern River were few in number. There might have been forty males in all. Of families, there were eight or ten. These people were engaged in agriculture, and irrigated 650 to 700 acres, all told. The water they used for irrigation, with the exception of what was applied on less than 20 acres, was taken from the old South Fork and Panama Slough. These two outlets of the river were then much larger than now, and carried the greater portion of the water of that stream. The works constructed for the reclamation of Swamp Land District No. 111, and the fluvial changes occasioned thereby, almost obliterated these channels at their head, and those irrigators who formerly drew water from them freely, have since, with great difficulty and expense, maintained a common connection with the river of limited capacity, by which they preserve their water rights and privileges. It is unnecessary in this report to go into a detailed description of the somewhat complicated system of individual water rights and ditches, connecting with these two channels, which have arisen from these fluvial changes. In the present condition of the main works the Old South Fork is used for about two miles at its head to divert water from the river into Panama Slough, and into a few minor distributing ditches to supply individual water rights, and occasionally as a feeder for the Kern Island Canal. Panama Slough is also occupied as the main channel of the Farmers' Canal.

The first canal in order on the river, located at the highest point on the left bank of the stream, is the Kern Island Canal, having a width at the head-gate of 48½ feet, a depth of 4 feet, and a length of 18 miles, terminating at Kern Lake. At the Town of Bakersfield the canal makes a vertical fall of nearly twenty feet, furnishing water power to a large flouring mill.

The canal has two main branches: the town branch, supplying Bakersfield and vicinity (formerly an independent ditch from South Fork, and one of the oldest in the valley), having a length of two miles; and the central branch, diverging from the canal south of the town, and running nearly parallel to it, and one to two miles east, for a distance of ten miles; having a width of 20 feet on the bottom, a depth of 3 ft., with slopes of 3 to 1. The main channel was originally built without drops or regulators, but the grade (about 7 feet per mile) was so excessive that great erosion resulted, washing away the banks, filling and widening the channel on its lower portion, lessening its capacity, wasting the water, and nearly ruining the canal for the purposes intended. These defects have recently been in a great measure remedied by a reconstruction of the channel, with drops placed at intervals. The experience in this regard was heeded in constructing the central branch, and it is one of the best irrigation canals in the valley. It has no less than 19 drops in a distance of ten miles, placed at intervals of about half a mile, and costing about $200 each.

There are 31 lateral ditches from this canal and its branches, having a total length of 80 miles. They were built and are owned by the individual land owners.

Old South Fork Canal.

Next below the Kern Island Canal is the channel before referred

to, known as Old South Fork, 20 feet wide at its headgate, 2 to 3 feet deep, and 2 miles long. One of its principal distributaries is the Cotton Ranch Ditch, irrigating about 1,100 acres of alluvial bottom lands north of Bakersfield. The greater portion of the water diverted into the Old South Fork is turned into the Panama Slough, and diverted again below by the Panama Ditch.

The Farmers' Canal.

The headworks of the Farmers' Canal are located 350 feet above the Southern Pacific Railroad bridge, and consist of wooden headgate, with 48 feet opening, fronting parallel with the river, the water entering the canal at right angles to the stream. Great difficulty has been experienced in making any structure hold its position, the first two having been undermined and removed since 1873, and the present one does not appear to be particularly secure. The artificial channel of the canal is less than one mile in length, being only sufficient to connect with the Panama Slough, which is occupied in common by the waters of the Farmers' Canal and those supplied to it by the old South Fork the whole distance of its course to Kern Lake, some 15 miles. This natural channel is six to ten feet deep, of irregular width, 20 to 50 feet, and having nearly vertical banks. The soil through which it passes is generally a firm clayey loam. The water is raised to the surface and diverted into the various distributing ditches by means of dams of wood or brush, which serve to promote the natural irrigation of the adjacent lands by percolation. A great deal of the land lying along the old channel is thus kept constantly moist, and requires no direct irrigation. Even below the point where any water is diverted into lateral distributing ditches, the waste water of the slough is held in check and utilized by means of brush dams which force it to percolate into the adjoining lands. There are six lateral ditches on the east side of the Panama Slough, with a total length of 32 miles, and four on the west side, 16 miles long in the aggregate. Total length of distributaries, 48 miles. No definite means are employed to divide the water between the South Fork owners and the Farmers' Canal stockholders, although in times of scarcity an overseer is employed whose duty is to see that all get their proportionate share.

The Castro Ditch.

This ditch derives water at the head of Old River, is 15 feet wide at the headgate, five miles long, and two feet deep. It crosses Panama Slough and irrigates a small amount of land east of that channel.

The Stine Canal.

The Stine is the lowest in the district, and next to the Kern Island Canal, is the most important. It occupies the bed of Old River for a distance of half a mile, and is then diverted into a channel having a general width of 20 feet on the bottom, a depth of three feet, with side slopes of one to one, and a length of 15 miles, the size diminishing considerably toward its lower end. The structure at the head of Old River is 80 feet in width, having the general form of all the headgates in that section. At the head of the canal proper is a structure 25 feet in width, with a regulating sluice adjoining in Old River, 40 feet wide.

The canal has two main branches, with numerous forks, varying

in width from 12 to 20 feet on the bottom, and having an aggregate length of 32½ miles, with 4½ miles of distributaries.

Recapitulation.

To recapitulate: The canal system of District No. 1 consists of five principal channels, with main branches, having an aggregate length of 110 miles, and 130 to 150 miles of distributing ditches. Total capacity of canals, 895 cubic feet per second. Estimated cost of main works, $298,000. Acres irrigated in 1879, 22,750. The system presents such an intricate net-work of canals and ditches, crossing and recrossing each other, that the lands irrigated by each are almost impossible to define.

The first seven months of the past year (1879) these channels diverted from the river an aggregate quantity of 5,121,219,200 cubic feet—an average of 279.4 cubic feet per second during the whole time. This average, divided into the total number of acres irrigated, gives an average of 81.4 acres irrigated by each cubic foot per second, or 225,109 cubic feet per acre—sufficient to have covered the land to an average depth of 5.17 feet, or 1.47 feet over the whole district.

District No. 2.

The canals and ditches of this district are: The Anderson (or Baker & Noble), the Gates, the Buena Vista, the James, the Plunkett, the Meacham, the Wilson, the Henley, and the Frazier, named in the order of their position descending the river.

The Anderson Canal heads at the junction of Old River and the main channel of the stream, the headgate connecting with those of the Stine across Old River and the Castro, the same system of wing dams serving for all. The canal is four miles long, 15 feet wide on bottom and two to three feet deep.

The Gates Canal has a total length of 2½ miles, a bottom width of 12 feet, and a depth of two to two and a half feet.

The Buena Vista Canal runs in a southwesterly direction 13¼ miles, is 30 feet wide on the bottom, and two and a half to three feet deep.

The James Canal heads near the head of the Buena Vista Canal, is 17¼ miles long, 40 wide, and three feet deep. It terminates within a short distance of Buena Vista Lake, having been extended for the purpose of supplying the Lake Ranch, upon which the experiment before mentioned in the cultivation of alkaline adobe lands was attempted. The lower half of the canal is now, however, disused. Like all the other principal canals on Kern Island, the grade is reduced by the use of vertical overfall drops.

The Plunkett Canal is used exclusively upon the Belle View Ranch, and during the past year drew no water from the river at its head, but was fed by the James Canal. It is 3¾ miles long, 12 feet wide on the bottom and two to two and a half feet deep.

The Meacham Canal is three and a-half to four miles long, eight to ten feet wide on bottom, two to three feet deep.

The Wilson Canal has a total length of 2½ miles, is six to eight feet wide, and 2½ feet deep.

The Henley Canal is about 2½ miles long, three feet wide, and two deep.

Recapitulation.

The canal system of District 2 therefore consists of 50 miles of main canals. I have no data for estimating the length of distributaries, but they probably do not exceed 25 to 30 miles. Total cost of work, approximately estimated, $52,500.

Maximum capacity of canals, 348 cubic feet per second.

Acres irrigated in 1879, 7,620.

Water quantity diverted in 1879, January to July inclusive, 1,293,500,000 cubic feet, equal to an average discharge of 70.6 cubic feet per second during the whole period—an amount sufficient to have covered all the lands irrigated to a depth of 3.9 feet.

District No. 3.

The canals and ditches of this district are the following, named in the order of their position, descending the right bank of the river: The Railroad, the Wible, the Goose Lake, the Pioneer, the Edwards, the James & Dixon, the Johnson, Ashe's Ditch, May's Ditch, the Dixon & Joice Canal, and the Dixon Canal. The heads of the first four named are in a cluster, as near together as possible, near the southwest corner of township 29 south, range 27 east.

The Railroad Canal is but about 3,000 feet in length, discharging into Goose Lake Slough. It is 25 to 30 feet wide on bottom and 3 feet deep. Its headgate is 40 feet wide. The water entering it the past season was collected into the lower portion of the Wible Canal and used for irrigation.

The Wible Canal also discharges into Goose Lake Slough about 1,000 or 1,500 feet below the headgate, and its waters are diverted lower down into a ditch by which they are conveyed to the lands irrigated. It is 30 to 35 feet wide on bottom, 3 feet deep, with side slopes of 6 to 1. Its headgate is 56 feet wide.

The Goose Lake Canal enters Goose Lake Slough a short distance below its headgate. The latter has a width of 134 feet. The canal is 150 to 160 feet wide on the bottom, 3 feet deep, side slopes about 6 to 1. Its head has become filled with sand a foot or two in depth, and the canal drew no water in 1879.

The Pioneer Canal has a total length of 11½ miles, a bottom width at the head of 30 feet, a depth of 3 feet, and side slopes of about 2½ to 1.

A short distance below this cluster of canal headworks is the lower county wagon bridge over the river. In the construction of this bridge Haggin, Tevis & Carr were permitted to convert its foundation at the same time into a weir for the purpose of diverting the water into the canals. The weir was too slenderly and cheaply made to withstand a severe test, and a portion of it gave way in the high water of 1877–78. The structure is 400 feet in length, 20 feet in width, and cost, including the superstructure of the bridge, $7,000. The damaged portion has been restored, and it is now ready for use again. It is said that the effect of this weir across the river has been to cause the filling up of the bed with sand one to two feet for a long distance above it, a natural result of checking the current of the stream.

The Edwards Ditch, next below the Pioneer Canal, is two miles in length, 10 to 12 feet in width on the bottom, and about one foot deep. It is not in use at present.

The James & Dixon Canal was originally cut 30 feet wide on bottom. In the center there was subsequently cut a channel 10 feet wide and 1½ feet deep. The form of cross-section is therefore irreg-

ular. The canal empties into a shallow, sandy slough a few hundred feet below its head, joining with the Johnson Canal. Water is taken from this slough upon the McClung Ranch of Haggin & Carr on the north, by the Johnson Canal stockholders on the south, and upon Haggin & Carr's Buena Vista Ranch near its western terminus.

The Johnson Canal is located on the river below the James & Dixon, and within a few feet of it, the waters of the two joining together in the slough spoken of. The canal at the head is ten feet wide on bottom, three feet deep, with side slopes of two to one. The headgate is 27½ feet wide.

Ashe's Ditch is one mile in length, eight feet wide on bottom, and two feet deep.

May's Ditch is two miles long, eight feet wide on bottom, and two feet deep. It was not used in 1879, and will not draw water until the river at its head is flowing two feet deep.

The Dixon & Joice Canal is three and one-half to four miles long, five feet wide on bottom, and two feet deep.

The Dixon Canal is two and one-half miles long, six to eight feet wide on bottom, and one and one-half feet deep. It diverts water through the Dixon & Joice Canal for about two and one-half miles, and branches out to the northwestward, irrigating lands on the borders of the reclaimed swamp in District No. 4.

Recapitulation.

The canal system of District No. 3 consists, as will be seen, of eleven main channels of greater or less size, having a total length of about twenty-five miles, with forty or fifty miles of distributing ditches. The main works have an estimated discharging capacity in the aggregate of 1,974 cubic feet per second. During the first seven months of the past season these canals diverted 1,232,500,000 cubic feet of water, an average of 67.3 cubic feet per second. The lands irrigated in the district cover an area of 3,860 acres. The water diverted, therefore, accomplished an average duty of 67.3 acres, and was sufficient to have covered the lands irrigated to a depth of 7.33 feet.

The total cost of the main works is estimated, approximately, at $63,000.

District No. 4.

The works of this district consist of the two canals constructed by the Kern Valley Water Company for the reclamation of Swamp Land District No. 121. The principal canal is that on the west side of the district, following, generally, the border of the swamp lands for a distance of 24 miles. At its head it is 125 feet wide on the bottom, seven feet deep, with side slopes of from three to one to seven to one, and a grade of 0.9 feet per mile. The grade is irregular, and runs as follows: One and one-half miles, 0.9 grade; nine miles, 2 feet grade; one-half mile, 2.5 feet grade; one and one-fourth miles, level; vertical drop, 1.6 feet; one mile, 8 feet grade; one and one-half miles, level; one and one-fourth miles, 2.4 feet grade; six and one-fourth miles, level; vertical drop, 2 feet; two miles, level. Below the main canal a parallel distributing canal, thirty feet wide on the bottom and two feet deep, was constructed for about ten miles. On the east side of the swamp a canal was constructed for irrigation purposes, having a bottom width of twenty-five feet, a depth of three to five feet, and side slopes of three to one.

The whole cost of these works, including a large levee across the

outlet of Buena Vista Lake, and another levee from the head of the canals eastward to the high land, slightly elevated above the swamp, was $324,000, of which $18,000 was for repairs of damages caused by the flood of 1877–78.

The extensive scale upon which these works were planned, and the results which have followed, are of peculiar interest; and I shall briefly outline them.

The main canal was intended to direct the flood waters of Kern River, and the overflow of Kern and Buena Vista Lakes, that have formerly sought an outlet to Tulare Lake across a belt of swamp lands 50 miles long, away from those lands through the artificial channel thus provided. It was also proposed to use the canal for the irrigation of the swamp lands after reclamation, and as a navigable channel connecting with Tulare Lake. To provide a permanent supply of water for irrigation it was intended to extend the canal south to Buena Vista Lake, and using that lake and the adjacent Kern Lake as reservoirs, to draw upon them for a regular supply. To increase their reservoir capacity it was intended to construct a high levee on their northern and eastern sides, first draining them dry by the canal, to render the soil on the line of the proposed levee dry enough to work. The lakes confined by the proposed levee would have a surface area of about 50 square miles, and contain about 14,000 million cubic feet of water, yielding a continuous discharge of 440 cubic feet per second for a year, without allowance for evaporation, or 660 cubic feet per second for six months of the year, estimating for evaporation. The reservoir was to be filled by the surplus flood waters of the river.

This plan was not fully carried out. The lakes were not converted into reservoirs. Other parties claimed them as swamp lands, litigation ensued, and so the works remain in a fragmentary and unfinished condition.

The lands have been reclaimed, so far as draining them and preventing overflow are concerned, but they are without a permanent supply of water for irrigation, which is as essential for their conversion into agricultural lands as their protection from occasional inundation. In ordinary seasons Kern River will for several months carry sufficient volume of water to admit of a surplus over and above that diverted into canals higher up, to run to its mouth and enter the canal; but this supply is precarious, and difficult to control after it is received. The past season water flowed into the canal but a few days in the month of May. All the rest of the season the canals above diverted all that flowed in the river. A large volume of water passed down the canal in 1878, from February 20th, when the first flood-wave came down the river, until about June 1st, ceasing entirely to run about July 20th. The effect of the first rush of water was to melt the alkali banks of the canal, causing innumerable breaks 50 to 1,000 feet wide, eroding the bed in holes five to fifteen feet deep, and washing out two large weirs.

District No. 5.

The canals of this district are the following: The Beardsley, the McCord, the Calloway, the McCaffrey, the Emery, and the Jones & Tuckey.

The Beardsley Canal is the highest channel taken from the river, It is eight miles in length, 15 feet wide on the bottom, 2 to 2½ feet deep. with side slopes of about two to one, and having a grade of 0.8 feet per mile. For the small volume of water carried, the grade is too

light, and great expense is entailed in clearing out the growth of weeds, joint-grass, and moss, permitted by the sluggish current of the canal. The enlargement of the canal is contemplated, which will remedy this defect. The canal has about 10 miles of distributing ditches.

The McCord Canal has a total length of 4¼ miles, with three branches, having a total length of 10 miles, and about 15 miles of distributing ditches. The main canal is 20 feet wide on the bottom, two and three feet deep, with irregular side slopes. These two canals are the means of supply for that portion of the district above the Calloway Canal.

The Calloway Canal, the most important work in the district, heads a short distance above the Southern Pacific Railroad bridge, occupying the bed of an old slough for about three miles, from which it is diverted into an artificial channel 60 feet wide on the bottom at its head, 40 feet on bottom a few miles below, and 80 feet on bottom at the lower end. It has a depth of about four feet, with side slopes of four to one. The total length at present completed is 30¾ miles. The grade is 0.8 feet per mile for 18 miles, when it is diminished to 0.4 feet per mile, to admit of locating the canal upon higher ground and covering more land. On the thirtieth mile the canal is carried across Posa Creek, by means of a weir 150 feet in length, built in the bed of the creek, and connecting at either end with the lower bank of the canal. This arrangement admits of the use of the winter waters of Posa Creek by diverting them into the canal. There are 36 distributing ditches eight to twenty feet wide on bottom leading from the canal, one to five miles long, having an aggregate length—as far as completed at present—of about 75 miles.

The McCaffrey Ditch is three miles long, seven to eight feet wide on bottom, and two and one-half feet deep. It irrigates land between the Calloway Slough and the river.

The Emery Ditch is three miles long, six to eight feet wide on bottom, and two feet deep. It passes over a very sandy stretch of country, with considerable loss by percolation.

The Jones & Tuckey Ditch is four miles long, ten feet wide on bottom, two feet deep, with side slopes of about two and one-half to one.

Recapitulation.

The entire canal system for the district consists, therefore, of 63 miles of main canal and branches and about 105 miles of distributing ditches.

The entire capacity of the canals is 675 cubic feet per second.

During the first seven months of the past season they diverted from the river 2,540,000,000 cubic feet of water—an average of 138.6 cubic feet per second during the whole period. The land irrigated was about 3,000 acres, and the duty of the waters diverted was but 21.7 acres per cubic foot per second.

District No. 6.

In District No. 6 no canals have been completed. On the Rio Bravo Ranch two ditches are in process of construction, intended to irrigate 1,000 to 1,500 acres.

SUMMARY.

The following table gives a summary of the detailed information in the foregoing pages, by district, with comparison of cost of works. Tables of more complete statistics of the entire canal system have also been prepared:

TABLE

Showing the length, cost, and capacity of canals in Kern County, the area of irrigable and irrigated land, and the average cost of canals per acre.

Number of Districts.	Total length of main canals and branches, in miles	Total length of distributing ditches, in miles	Total area of district	Area probably susceptible of profitable cultivation	Acres irrigated, 1879	Total capacity of canals constructed, in cubic feet per second—estimated	To tal cost of main works not including distributing ditches—approximate	Average cost of main works per acre irrigated	Average cost of works per acre of irrigable land in district	Average cost of main works per acre irrigable with the maximum discharge of canals. Under a duty of 50 acres per second-foot	Under a duty of 100 acres per second-foot	Under a duty of 150 acres per second-foot
No. 1—Between South Fork and Old River	110	140	80,000	75,000	22,750	895	$298,000	$13 10	$3 97	$6 66	$3 33	$2 22
No. 2—West of Old River and south of New River	50	30	64,000	50,000	7,620	348	52,500	6 89	1 05	3 02	1 51	1 00
No. 3—Between Goose Lake Slough and Kern River	25	45	70,000	40,000	*5,000	1,974	63,000	12 50	1 57	0 64	0 32	0 21
No. 4—Swamp Land Districts 121, 184, 185, and 208	27	10	103,000	90,000		3,370	324,000		3 60	1 92	0 96	0 64
No. 5—Above Calloway Canal and below Beardsley	22	25	60,000	50,000	1,215	80	22,500	18 18	0 45	5 62	2 81	1 87
No. 5—Below Calloway Canal	41	80	300,000	110,000	3,355	595	89,000	26 53	0 81	3 00	1 50	1 00
No. 6—East of Kern Island	00	00	70,000	60,000								
Totals	275	330	757,000	475,000		7,262	$849,000					

* Not all irrigated in 1879.

Remarks on table.

In making comparisons of the cost per acre of the various works, some explanation of the figures presented by the foregoing table is necessary. The average cost per acre of the lands irrigable in District No. 1, for example, shows considerably higher than the others, because the canal system of that district is more nearly completed and commands the whole district more completely than the systems of any other district. The averages shown in the last three columns are small for District No. 3, owing to the large capacity of two canals—the Railroad and the Goose Lake—which, at present, consist only of a headgate and a short channel leading therefrom to Goose Lake Slough, the cost of which was slight compared with their capacity for diversion of water.

PRACTICE OF IRRIGATION.

EXTENT OF IRRIGATION IN KERN COUNTY.

The total area of land irrigated in Kern Valley from Kern River, in 1879, was 38,800 acres, of which about one third (according to an approximate estimate) was devoted to alfalfa, and the remainder to cereals—chiefly wheat and barley, Indian corn, potatoes, and miscellaneous products. This comprises almost the whole of the lands under cultivation in the valley, as but few acres were in cultivation which were not irrigated directly by surface flooding, or indirectly by percolation from artificial channels or natural watercourses, used as irrigating canals. Of this area, probably one fifth had never been irrigated prior to 1879.

Prior to 1873 comparatively little land was irrigated. The only canals existing at the beginning of that year were the (1) Kern Island, completed only to Bakersfield, and irrigating a limited amount of land around the town; (2) the ditches taking water from the Old South Fork, irrigating a few hundred acres north of Bakersfield and in the vicinity of the old settlement of Panama; (3) the Castro Ditch; (4) the Stine, partially completed by farmers who had formerly taken water directly from Old River at different points; (5) the Buena Vista, supplying what was known as the Barnes Settlement by means of an old natural slough, which has since been abandoned for an artificial channel, cut on higher ground, nearly parallel to the slough; (6) and the James Canal, then a much smaller channel than it now is. The total amount irrigated by these probably did not exceed 5,000 acres. No water was diverted on the north side of the river.

In 1873–4 H. P. Livermore and Haggin, Tevis & Carr began the development of their large estates, and progress in the construction of canals, clearing and cultivation of land, and enlargement of irrigation, has since then been rapid and constant. No new canals from the river have been taken out in the last two years, but many of those already in existence have been much improved and extended, a work which will doubtless continue until all the land susceptible of irrigation with the water supply afforded is brought under cultivation.

To accomplish, during the last season, the irrigation of the area above stated, the whole of the available water supply of Kern River

excepting that unavoidably lost in transit to the lands was used. Our tables of river and canal discharges, based upon numerous gauging observations and a daily rod-record kept of each canal, show that in the period from January 1st, 1879 (when our observations began), to July 31st of the same year, the discharge of the river at the Rio Bravo Ranch, about 14 miles above the Southern Pacific Railroad bridge, was 12,557,679,000 cubic feet, while the canals diverted an aggregate of 10,184,000,000 cubic feet (an average of 555.9 cubic feet per second), in the same period, or 81.1 per cent. of the whole amount passing out of the mouth of the cañon, the remaining 18.9 per cent having been lost in the river bed below the cañon and before reaching the lower canals, by percolation and by evaporation.

Special gaugings.

A number of special gaugings of the principal canals were made during the months of June and July, for the purpose of ascertaining the probable loss of water from various causes in the canals themselves. From these gaugings and other observations certain percentages were adopted for each canal representing the amount of loss in transit to the lands irrigated, the probable wastage in sloughs, waste lands, etc., and the quantity escaping at the termini of the canals and ditches. Deducting these percentages, the total quantity actually applied to the 38,800 acres irrigated during the period named, was estimated at 6,813,625,000 cubic feet (an average of 372 cubic feet per second), sufficient to have covered the lands irrigated to a depth of 4.03 feet.

Total loss.

This shows an aggregate loss of 33 per cent. of the whole amount diverted from the river, and is 54¼ per cent. of the whole amount discharged by the river at the mouth of the cañon.

Average duty of water.

The average area irrigated per cubic foot per second diverted from the river was 69.8 acres, and the average per cubic foot per second probably applied 104.3 acres.

The following table shows the amount of water diverted from the river by each canal, the probable amount actually applied to the lands, the percentages of loss and waste, and the average duty accomplished by the cubic foot per second flowing continuously through the irrigating season of seven months, January to July inclusive:

TABLE

Showing the Quantity of Water Diverted from Kern River, for Irrigation, etcetera—Season of 1879.

Name of Canal.	Total number of acres irrigated	Total amount of water taken from Kern River for irrigation, January to July, inclusive	Average discharge per second, in cubic feet	Total number of cubic feet of water per acre	Average depth to which water taken from river would cover land irrigated, if all applied	Probable loss in canals, in transit to lands, and wasted on wild lands, etc	Probable quantity actually applied, in cubic feet, per acre	Average number of acres irrigated per second-foot of water taken from river	Average number of acres irrigated per second-foot of water applied	Total depth of water applied	Equivalent area, one irrigation	Average depth of water on land per irrigation
North Side:—												
Beardsley	450	155,000,000	8.4	344,444	7.9	40 pr ct.	206,666	53.6	88.7	4.74	1,350	1.58
Calloway	3,000	1,760,000,000	96.0	586,667	13.47	40 "	352,000	31.25	50.2	8.08	9,000	2.69
McCord	765	320,000,000	17.5	418,300	9.6	50 "	209,150	43.7	87.4	4.80	2,295	1.60
McCaffrey	280	177,000,000	9.7	632,143	14.5	60 "	252,857	28.9	72.2	5.80	840	1.93
Emery	20	60,000,000	3.2	3,000,000	68.8	90 "	300,000	6.25	62.5	6.88	120	1.15
Jones & Tuckey	55	68,000,000	3.7	1,236,363	28.4	80 "	247,273	14.9	74.5	5.68	110	2.84
Wible	260	131,000,000	7.2	619,230	14.2	60 "	185,769	29.2	73.0	5.68	520	2.84
Railroad		31,000,000	1.7									
Pioneer	3,450	877,000,000	47.8	254,203	5.9	30 "	177,942	72.2	103.1	4.13	5,000	2.82
*James & Dixon		*54,000,000	3.0									
†Johnson	150	94,500,000	5.2	630,000	14.46	40 "	†378,000	28.85	48.1	8.68	300	4.34
‡Dixon & Joice		‡45,000,000	2.4									
South Side:—												
Kern Island	9,860	1,910,000,000	104.2	193,712	4.4	25 "	145,284	94.6	126.2	3.3	19,720	1.65
Farmers'	5,344	840,000,000	45.8	254,676	5.85	30 "	178,273	70.0	102.9	4.1	7,770	2.82
Old South Fork		521,000,000	28.4									
Spanish, or Castro	300	86,000,000	4.7	286,666	6.6	35 "	186,333	63.8	98.2	3.99	600	2.00
Stine	7,245	1,761,000,000	96.1	243,064	5.6	30 "	170,145	75.4	107.7	3.92	11,590	2.40
Baker & Noble	1,140	200,000,000	10.9	175,439	4.0	15 "	149,123	104.6	123.0	3.40	2,280	1.70
Gates	325	59,000,000	3.2	181,538	4.1	15 "	154,307	101.6	119.5	3.48	650	1.74
Buena Vista	1,920	418,500,000	22.9	217,974	5.0	25 "	163,481	83.9	111.8	3.75	480	1.50
James	3,400	556,000,000	30.3	163,529	3.75	25 "	122,647	112.2	149.6	2.81	6,800	1.40
Plunkett												
§Meacham	785	51,000,000	2.8	§65,000	1.5	10 "	58,500	280.4	311.5	1.35	785	1.35
Wilson	52	9,000,000	0.5	173,077	4.0	10 "	155,770	104.0	115.5	3.60	104	1.80
Total	38,801	10,184,000,000	555.6									

Discharge of river at cañon	12,557,679,000	685.9
Loss in river below mouth of cañon	2,373,679,000	130.3=18.9 per cent.

*Wasted in slough †Approximate. ‡Used only for stock. §Exceptional.

DUTY OF WATER.

The average duty of water varies not only with the character and depth of the soil, but with the crops irrigated. It is generally higher with cereals than with corn or other summer crops, as the time between irrigations is usually longer and the number of waterings required to mature a crop less. This is accounted for by the fact that cereals are irrigated in the winter and spring, when evaporation is least, and the artificial wetting is more or less supplemented by rainfall.

But before drawing conclusions as to what the duty of water now is, or what it may become, a general description of the methods and systems of irrigation in vogue in the section under consideration will be given, as far as they fell under my observation.

IRRIGATION PERIODS.

The year may be divided into four irrigation periods—as follows:

First Period—November, December, and January.

The most experienced, thrifty, and successful farmers of Kern County prefer to give their lands a thorough soaking prior to the sowing of cereals, as a matter of precaution against the results of a dry season, and therefore apply water some time during the months of November, December, or January. The advantages of this practice are:

1. Early grain generally makes the best yield; it gets a start before the weeds, which so frequently overrun and destroy late grain, and hence is cleaner also.

2. In case the season should be one of drouth, the lands irrigated early do not suffer if they do not receive water at the later period of general demand.

The majority of farmers, however, are always hopeful of a favorable season, and if there is any probability of sufficient rainfall to sprout their grain, will delay seeding as late as January 15th or February 1st, when, if there has been but little rain, they are at last compelled to irrigate to prepare their land for plowing. They delay this first watering not only to save the expense of one irrigation, but, as they claim, because the ground is better prepared by rain than they can possibly do it with irrigation, and the grain starts better. In a section where the rainfall is generally so very light, the hazard of delay in putting in crops is too great to give weight to the advantages claimed, and it is probable that the system of winter irrigation will, in time, prevail, and that period become one of as great demand as the subsequent period of spring irrigations.

Alfalfa begins to start (after having been killed down by winter frosts) about the middle of January, when it is given a watering, if the rain has not been sufficient to bring it forward.

Second Period—February, March, and April.

In seasons where the rainfall reaches five or six inches, and where the soil is not too porous or an impervious subsoil too deep, one irrigation of grain, whether sprouted by rain or by artificial watering, is

sufficient to mature it. This irrigation is applied sometime during the months of February, March, and April, according to the stage of growth. Early sown grain will generally require but one irrigation, but in a *dry* season, like the last, two irrigations during this period are deemed necessary, especially for late grain, although the last one may occur as late as the month of May.

Late irrigation of grain.

After grain has obtained a vigorous first growth from moisture received prior to sowing, either naturally or artificially, there appears to be an advantage in delaying the first irrigation until the young plants begin to turn yellow and seem about to die, for otherwise there would be danger of its receiving an excess of moisture at the improper time, stimulating a rank growth of straw at the expense of the grain.

Influence of soils.

On land that receives the benefit of percolation from the canals, more than one irrigation in the second period is never required, while on soils of non-percolating character three, or even four, waterings may be necessary, dependent upon its texture and the depth and nature of the subsoil.

Third Period—May, June, and July.

Summer irrigation.

This is more properly the season of irrigation for corn and alfalfa, as the bulk of the area of cereals will have got beyond the necessity of further irrigation.

Irrigation for corn.

Corn land must always be wet prior to plowing or planting, and, for early crops, this begins in May, although where corn follows grain as a second crop it is delayed until June or the beginning of July. Corn grows rapidly, and its general irrigation will have been entirely completed by the end of July. The number of waterings required depends, like that of cereals, upon the quality of the soil, one irrigation being sometimes sufficient to mature it, while three or four may be necessary.

Fourth Period—August, September, and October.

Fall irrigation.

After July no general irrigation is practiced except for alfalfa, late potatoes, and vegetables, although water is run in all the canals for stock purposes.

Alfalfa soils.

Alfalfa is irrigated at any time during the year from January to October, and while there is much of it that is never irrigated, receiving moisture from the permanent stratum of surface water which in places its roots find at a depth of five to six feet, on other soils less favorable to its growth, it may be necessary to water it every five to six weeks from the latter part of January to the 1st of October. The mean between these extremes in alfalfa lands is a compact alluvial soil, which retains moisture a long time and requires not more than two or three irrigations in the whole season.

METHODS OF IRRIGATION PRACTICED.

Flooding.

The method of irrigation most generally in vogue is that of flooding the surface of the land with a thin sheet or layer of water. This is accomplished in two ways; by means of small distributing ditches running through the fields and following the highest ground from which the water runs down the slopes in a thin sheet over the surface, or by means of check levees, which hold the water in level ponds temporarily upon the ground.

The spreading plan.

The former system costs least in the preparation of the ground, as the ditches are cheaply made, being generally thrown out with a plow, finished and enlarged if necessary by a "V" shaped scraper or "hone;" but the cost of applying water is much greater than by any other means, its diversion over all the irregularities of surface is necessarily slow and great skill is required to accomplish the uniform wetting of the whole, that one portion may not receive too much and another portion too little.

The checking plan.

In the check system low levees are thrown up one and one-half to two feet high, on contour level lines, eight inches to one foot apart in vertical distance, and in horizontal distance as far apart as the slope of the ground will admit. Water is admitted between these check-banks, through gates from the main canal or large laterals that extend through the land, and allowed to run until the whole space inclosed in the levees is covered. The water will thus stand nearly to the top of the lower levee before the ground at the base of the levee next above is covered. When the check is full the water is either drawn off into the check next below, or if the ground be porous and dry, it is allowed to stand until it soaks away.

Its advantages.

The only labor attached to this system of irrigation is in opening and closing the gates, watching the levees, and repairing breaks that may occur. One man can thus accomplish much more than by the other system, as he may have a number of streams running at once. The first cost of preparing the ground is considerable, but the cheapness of subsequent irrigation justifies the cost on all ground of tolerably uniform surface.

Its disadvantages.

If the surface be very irregular the lower spots are likely to receive too much water, requiring careful attention to drainage and a diminution of the area of the levee-inclosed checks.

Check levees.

The best levees are constructed with a broad base of 15 to 20 feet, and when properly made can be driven over with any farming machinery in any direction, being simply a gentle swell in the land, upon which crops grow as well as upon any other portion of the field. The most systematic and best constructed check levees I saw in Kern County, or in any other portion of the State, were those recently built by Haggin, Tevis & Carr upon the lands irrigated by the Calloway Canal.

Cost of checking.

The average cost per acre of 5,956 acres prepared in this way, was as follows: Earthwork, $1 64; waste or drainage gates, $0 51; total, $2 15. The average cost of lateral canals, including necessary regulators and side gates to supply the land, was $4 00 per acre, making the total cost of preparation of ground $6 15 per acre.

Checks and ditches.

These check levees are built upon one foot contours with about 20 feet base; the lateral canals are from one-fourth to one-half mile apart, and the checks range from ten to fifty acres in area. From 15 to 20 miles of check levees are required per square mile of land, and a mile of levee contains 3,080 cubic yards. The soil is a sandy loam, easily worked, and the cost of preparation shown above is probably less than the average cost of such works elsewhere.

Cheap check levees.

A more common, because a cheaper, manner of building the check levees, is to make them on a very narrow base, with sides as steep as the material will stand. This kind of levee cannot be driven over with any sort of farming implements, and are thus far an impediment to the cultivation of the land, as they must either be plowed down every year and rebuilt again, or each particular check must be cultivated and harvested as an independent field.

Checking and spreading.

Of the two systems of flooding named, that by small ditches is practiced on at least three-fourths of the total area irrigated. The check system is, however, coming into more general use, and will, doubtless, be the principal method adopted for future extension of the irrigated area.

The ditching plan.

A third method of irrigation is the furrow system, water in small streams being turned into parallel plow furrows, wetting the adjacent land by percolation. This method can be practiced only on the more porous soils, and is confined chiefly to the irrigation of corn, potatoes, and other crops that are cultivated in furrows.

Percolation.

Sub-surface irrigation, or the wetting of the ground by underground percolation, is practiced to a considerable extent, but the area over which the system is practicable is comparatively limited, and is confined to a few thousand acres on Kern Island. For this system the old channels, or blind sloughs, that ramify through the country, are used. These are, generally, but shallow troughs, with flat sloping sides. Temporary dams are thrown across them, and they are filled with water from the nearest ditch. Percolation from them extends from 500 to 1,500 feet laterally. Where there are no natural channels convenient the fields are surrounded by ditches, which are kept full of standing water as long as may be necessary to wet the inclosed field. A great deal of land in various portions of Kern Island is thus sub-irrigated by the natural percolation from the canals.

Time of percolation.

Percolation is usually greatest the first year a new canal is used,

before the soil becomes settled and the channel is puddled with sedimentary deposits. On the two branches of the Stine Canal, used last year for the first time, it is estimated that at least 4,000 acres were irrigated sufficiently by natural infiltration. The great quantity of water lost from the canals in passing over these soils is thus partially utilized.

Soil best adapted for percolation.

The soil in which sub irrigation is most perfect is a light vegetable loam, mixed with sand and gravel, and underlaid with clay or some other retentive substratum. Where the quantity of water given to the soil can, in a measure, be controlled, the crops raised by sub irrigation are greater than those produced by the application of water on the surface.

Quantity of Water required for Irrigation.

Variable results.

To illustrate the great variation in the quantity of water used on the various classes of soils, it is necessary to go into detail and mention a number of examples.

In District No. 1.

Commencing with District No. 1, Kern Island: the black alluvial bottom lands north and northwest of Bakersfield are kept constantly moist below the surface by percolation from the river and from Old South Fork, but alfalfa requires two irrigations a year, and other crops one to two. Of the actual amount of water absorbed, no data could be obtained.

Chinese gardeners.

The Chinese gardeners in the vicinity of the town, use almost incredible quantities of water. Celsus Brower, Esq., the Secretary of the Kern Island Irrigating Canal Company, from whom these gardeners purchased water, kindly furnished a statement of the amounts used by a number of them, as well as the quantities purchased by other irrigators, which has been made a basis of calculation in some of the following examples. As the system of measurement in vogue is tolerably uniform, I was enabled to calculate the quantity used with some degree of accuracy. The following table is given of the quantities used by some of the Chinese gardeners:

Garden irrigation.

Name.	Area of land irrigated—acres	Total number of cubic feet of water used	Average depth of water used on land, in feet	Cost per acre—water	Period of irrigation.
Sin Mon	30.	5,320,800	4.07	$1 97	Dec., Feb'y, March, April, May, and June.
Ah Cow	0.8	1,331,840	38.20	20 00	Feb'y, April, May, and June.
Ah Gee	50.	6,375,600	3.00	1 42	Jan'y, March, April, May, and June.
Ah Song	3.2	2,751,200	19.70	10 00	Jan'y, Feb'y, March, April, May, and June.
Ah Lung	3.2	2,322,432	17.	6 17½	Feb'y, March, April, May, and June.
Sing Lee	10.	1,658,880	3.8	1 92	April, May, and June.

Head used.

The smaller of the gardens irrigated have a continuous stream of 6 to 12 "inches" running continuously, day and night. These streams are sold at special rates, which will be referred to hereafter.

Second Example.—On sections one and two, two miles south and west of Bakersfield, along Panama Slough, where the land receives the percolation of several channels, natural and artificial, a field of 50 acres of alfalfa is irrigated in six days and nights with a stream equal to 1½ cubic feet per second, and an orchard of 20 acres is irrigated in two days and one night with the same amount. The discharge would be equivalent to a depth of 0.36 and 0.37 feet respectively over the land irrigated. Soil, alluvial loam. The orchard is irrigated once a month, and the alfalfa once or twice a year, or more when it is used as a pasture.

Third Example.—Section twelve, three miles south of Bakersfield, is said to require five times the water needed on the bottom lands north of town, although the soil is similar and lies between two canals. The surface is a few feet higher than the surface of the canals. Crop, alfalfa.

Fourth Example.—Southeast ¼ Section 30, 6½ miles south of Bakersfield, irrigated first in 1878. Four acres can be irrigated in 24 hours, with 7 cubic feet per second. Allowing a loss of 1 cubic foot in transit from canal to lands, this amount would be equal to a depth of 3 feet over the whole area. Soil, sandy loam. Surface water at a depth of 6 feet, rising to 3 feet after irrigation, and subsiding again. Crop, wheat, barley, beans, sweet potatoes, alfalfa, orchard, and small fruits. Water used in 1878 cost $1 03 per acre, and in 1879, 81 cents per acre.

Fifth Example.—Southwest ¼ Section 31, 7½ miles south of Bakersfield. First irrigation of 40 acres, in May and June, 1879, was effected with 1,209,600 cubic feet of water, equivalent to a depth of 0.7 feet over the whole area. Land thoroughly soaked in spring by a break in the canal, and receiving benefit of constant percolation. Cost per acre of the only irrigation given, 25 cents. Soil, sandy loam, containing decayed vegetable matter. Crop, cereals.

Sixth Example.—Section 32, 7½ miles south of Bakersfield. From July 23d to 29th, inclusive, 6 days, 40 acres were thoroughly saturated with a discharge of 7.73 cubic feet per second; equivalent to a depth of 2.30 feet over the whole area. The land had been irrigated but once before this season, the first week of May. It was dry to a depth of six inches, while surface water stood at a depth of 3.75 feet below surface. The land was first irrigated in the spring of 1878, when surface water stood at a depth of 17½ feet. After first irrigation, it rose to twelve feet, and after first irrigation, in 1879, rose to 3.75 feet, where it remains. Soil, alluvial sandy loam, mixed with partially decayed tule roots to a depth of 17 feet, and underlaid by a stratum of clay 12 to 14 inches thick. Crop, wheat, barley, alfalfa, corn. Average number of irrigations during the season, about 1½. Average cost of water per acre, 70 cents. Average cost of labor (Chinese) per irrigation, 8 to 10 cents. Part of land irrigated by the check system, part by the small ditch system.

Seventh Example.—Sec. 5, T. 31 S., R. 28 E., eight and one-half miles from Bakersfield, adjoining the last-named section, with similar soil, and cultivated the same length of time. A record was kept of the quantity of water used for the second irrigation of a tract of 150 acres

of corn. The total discharge in 21 days was 16,004,736 cubic feet, sufficient to have covered the land to a depth of 2.45 feet. The land had been irrigated in February or March for wheat, but it was so late that only weeds sprouted. In June the land was irrigated again to prepare it for corn, and the last irrigation noted above was from July 23d to August 12th. Total cost of labor employed for the last irrigation of corn $80 50, or $53\frac{67}{100}$ cents per acre. Cost of water for same, $99 36, or $66\frac{24}{100}$ cents per acre. Total for water and labor, $1 20 per acre. Total cost of water used on the section during season, for 350 acres wheat and 150 acres corn, $452 32, or 90.5 cents per acre.

Eighth Example.—Sec. 7, T. 31 S., R. 28 E. The first irrigation of 50 acres of corn (the land having been wet before plowing in May), occupied ten days—July 21st to 30th, inclusive—with an average discharge of 7.2 cubic feet per second, equivalent to a depth of 2.86 feet over the whole area. Total cost for water, 31 cents per acre. Total cost of water for season for irrigation of 90 acres of wheat and barley, 50 acres of corn, and 70 acres of alfalfa, $0 55 per acre. Soil partially black, stiff loam—almost adobe in texture; partially loam, mixed with sand; part coarse sand, underlaid with quicksand. Most of the land under cultivation was irrigated this year for the first time. The ranch could nearly all be sub-irrigated, but the owner prefers the small-ditch system. He thinks that next year his land will absorb not more than one-half the water it has this year.

Ninth Example.—Sec's. 21, 28, and 33, T. 31 S., R. 28 E., and Sec. 4, T. 32 S., R. 28 E., 12 miles from Bakersfield, in the vicinity of Kern Lake, eight hundred acres of wheat, corn, and alfalfa, irrigated once, 250 irrigated twice, and 100 three times, required a total of 66,450,000 cubic feet of water during the season, equivalent to a depth 1.33 feet at each irrigation. Average cost of water, 50 cents per acre for the season. Soil, a stiff black loam, one to two and a half feet thick, underlaid with yellow clay, two to four feet thick, beneath which surface water is abundant in a stratum of sand. Moisture is also found above the clay, maintained by drainage of lands above.

Tenth Example.—Sec. 4, T. 31 S., R. 27 E. In one experiment $3\frac{1}{3}$ acres prepared with care, leveled, and checked with proper levees, were covered in 15 hours, with an average discharge of $2\frac{1}{3}$ cubic feet per second, equivalent to a depth of 0.87 feet over the whole area. Land lies adjacent to Panama Slough, from which it receives moisture by percolation. Soil, sandy loam, of considerable depth. Surface water eight feet below surface. Land had been irrigated four or five years.

Eleventh Example.—Livermore Ranch, sections 18, 20, 29, 30, 31, 32 (T. 31 S., R. 29 E.), and Sec. 5 (T. 32 S., R. 29 E.) Average number of waterings required, $1\frac{1}{2}$, (one general irrigation and a second irrigation on the drier spots.) Average cost per acre for labor of irrigation, 12 to 15 cents. Average cost for the season for labor and water, $1 50 per acre. Water was shut off from March 17th till May 15th, causing the failure of 300 acres of barley and 600 acres of wheat that had been dry sown. No data could be obtained as to the quantity of water used per acre. The ranch being at the terminus of the main canal and the central branch, the supply fluctuates, according to the demand from the lands above.

These examples are all taken from lands in District No. 1, mostly reclaimed swamp lands, requiring comparatively little water, as they are subject to percolation from numerous sources. Most of the lands

referred to are irrigated from the Kern Island Canal. This being the only canal in the county from which water is sold by measurement, the data afforded regarding the cost of irrigation and the quantity consumed are more definite and reliable than could be obtained elsewhere. Unfortunately I was called away from the county during the period of general irrigation, and did not have the opportunity of carrying out the series of observations and experiments I had intended, or of collecting the character of information most desirable in the determination of this subject, *i. e.*, the volume of water required for the production of crops, and the cost. A few other examples may be given as approximately correct, to illustrate the thirstiness of other classes of soils.

Twelfth Example—District No. 2, Belleview Ranch, Township 30 S., Range 27 E.—No exact data as to volume of water used could be obtained. The average number of irrigations required for cereals is two to three—one being sometimes sufficient in seasons of favorable rainfall. For alfalfa, three to four irrigations are generally needed; for corn, two are sufficient. Soil sandy, with streaks of heavy loam marking the course of old sloughs.

Thirteenth Example—District No. 3.—McClung Ranch, Secs. 3, 4, 5, and 6, T. 30 S., R. 26 E., and Sec. 1 in township adjoining. The first year of irrigation—1874—a ditch described as "twelve feet wide on bottom, two feet deep, with a good average flow," was discharged for seven months upon 100 acres before the land was saturated. If this be true, such a ditch, with side slopes of one to one, and grade of, say, two feet per mile, would have discharged enough water in that time to have covered the land 166 feet deep. The water was, of course, not confined to the immediate neighborhood of the tract upon which it was discharged, but spread for miles in underground channels, filling up the loose, porous soil several feet in depth. A large portion of this ranch is of the same thirsty character, and continues to absorb enormous quantities of water. The average head of water which one man can conveniently handle in irrigating is what will pass through a gate four feet wide, with a depth of overfall of about one foot, equivalent to about thirteen cubic feet per second; and with this from one to six acres a day (of twelve hours) can be irrigated. This discharge is sufficient to cover the land from six to thirteen feet deep. The land has been irrigated three to four years, and absorbs a trifle less each year; but if irrigation be suspended for one season the subsurface moisture drains away, and the following year much more water would be required than would have sufficed the previous year. This is the case, to a greater or less extent, in all parts of the valley of Kern River. On the lands cited in this example, one thorough soaking is sufficient to produce a crop of cereals, with enough rainfall to sprout the grain. With no rain, two irrigations are required, one to prepare the land, the other to mature the crop. Alfalfa requires three to four waterings through the season to maintain a vigorous growth. Soil, coarse sand and sandy loam of great depth.

Fourteenth Example—District No. 5.—Sec. 13, T. 29 S., R. 27 E. On a strip of bottom land, between the McCord Canal and the Calloway Slough, 80 acres of alfalfa have been irrigated in four days and nights with a discharge of about six cubic feet per second, sufficient to have covered the ground to a depth of 0.6 feet. The land had been irrigated for two to three years. Soil, alluvial loam, having an

elevation of but five or six feet above the river, and receiving constant moisture from below by percolation. The crop was irrigated twice during the season prior to August 1st.

Fifteenth Example—District No. 5.—Sec. 14, Tp. 29 S., R. 27 E. With a discharge equal to about 2 cubic feet per second, two acres of corn can be covered in a day of 12 hours, equivalent to a depth of about 2 feet over the whole area. This example was given as the fourth and last irrigation of the tract in the season, the land having been wet once before seeding and three times after. The land had been irrigated several years. Soil, brown sandy loam, one to six feet deep, underlaid with hardpan, not wholly impervious.

Sixteenth Example—District No. 5.—Sec. 8, Tp. 29 S., R. 27 E. Alfalfa requires irrigation twice a month. Wheat is irrigated twice after planting and once before. Corn requires five irrigations, the first of which is given before seeding, in May, the last in the latter part of July. Soil, sandy loam, two feet deep, underlaid with two feet of yellow hardpan. No data as to quantity of water required at each irrigation.

Seventeenth Example—District No. 5.—Sec. 27, T. 28 S., R. 26 E. First irrigated in 1879; wheat required three to four irrigations, one prior to sowing; land irrigated by the check system, by which two men could water 160 acres in four days, at a cost of about 10 cents per acre per irrigation, for labor; soil similar in character to that cited in foregoing example.

Eighteenth Example—District No. 5.—Sec. 9, T. 27 S., R. 25 E. Posa Ranch—A test was attempted to ascertain, if possible, the quantity of water absorbed by the desert lands on the plains north of Kern River, now supplied by the Calloway Canal. A check containing 3¾ acres was prepared, and water admitted in as great quantity as was expedient for the safety of the newly built banks about the gates. An hourly record of the head was kept, the discharge being from 4 to 9 cubic feet per second. Eleven hours were required to fill the check sufficiently to barely cover the highest ground when the water was shut off. Next morning all the water had soaked away. The quantity discharged was sufficient to have covered the whole area 1.75 feet in depth. A portion of the area doubtless absorbed five times as much as the higher spots, as the percolation seemed to be entirely downward and not in a lateral direction. Three weeks after, the check was filled in 4 hours and 12 minutes, with an average discharge of 13.35 cubic feet per second, covering the ground to an average depth of 1.25 feet. Some time between these two experiments the land was flooded by the breaking of a check above. The total quantity absorbed by the three waterings was probably not less than 4 to 5 feet. The soil is a brown sandy loam of an unknown depth, but probably greater than twenty feet to hardpan.

CONCLUSIONS.

These examples are sufficient to support the following conclusions:

Increase in duty.

First—That with the progress of irrigation the quantity of water absorbed by the land is constantly diminishing, and therefore the duty of water is growing greater in an equal ratio.

Sub-surface waters.

Second—The construction of irrigation channels carrying water over all parts of the irrigated districts, and the yearly enlargement of the area under cultivation, is rapidly filling the substrata with water, raising the general level of the sub-surface waters, and increasing the moisture in the soil, and that this result also effects the diminution of absorption and the increasing duty of water spoken of.

Influence of soils.

Third—That this effect is progressing more rapidly in some sections than in others, and that owing to the great variation in the character of the soil there will always continue to be a great variation in the duty of water.

Influence of period and crops.

Fourth—That the duty of water is greater for certain periods of the year, and with certain crops, than for other periods of the year in which crops requiring more frequent watering are grown. For example, during the months of December, January, February, March, and April, cereals would rarely require more than one irrigation. If, for purposes of illustration, we assume that an average depth of two feet of water is required at each irrigation, a cubic foot per second flowing during the period named would irrigate 150 acres, making no allowance for loss. When the time had arrived that but one foot in depth was necessary, 300 acres would be irrigated by the second-foot. In the subsequent months of May, June, and July, the crops of corn, alfalfa, potatoes, etc., require more frequent irrigation than the crops planted in the earlier periods, and therefore the duty of the second-foot of water would necessarily be less, presuming the ground to absorb no more at that season of the year than in the winter and spring. As the season of the greatest duty of water corresponds very nearly with that of the maximum discharge of the river, I am of opinion that in estimating the average duty of water, or the maximum irrigating capacity of the stream, a season covering but a portion of the year should be selected. In tabulating the canal discharges and duty of water on the various canals, I have taken this period as the first seven months of the year.

Further observations necessary.

Fifth—That the data collected, and the observations made, are too meager and extend over too short a time to render it possible to arrive at a satisfactory conclusion, as to the present or the ultimate duty of water. The table referred to shows the duty of water diverted from the river in 1879, January to July inclusive, to have been from 6 to 112 acres, and of the amount, probably actually applied, from 48 to 150 acres.

Systematic rotation.

Sixth—That the duty of water, although increasing with the progress of irrigation in time and extent, may be further increased by the adoption of a more systematic rotation in the distribution of water. The necessity for this has not heretofore been very urgently felt, but when a greater area is under cultivation it will be apparent, especially with the recurrence of a season of scarcity such as that of 1879 has been.

Seasons of demand.

The season of greatest demand is now confined to the months of February, March, and April, but by the adoption of a system of early sowing and winter irrigation this period of maximum demand may be extended over a longer period, beginning with November and ending in April or May, more fully utilizing the volume of the flood discharge of the river, which is often greatest in that period.

LOSS OF WATER.

Observations.

Reference has been made in the foregoing to experiments conducted for the determination of loss of water in the canals. These experiments consisted of free-float gaugings at various points along the canals, and of careful measurements over weirs, wherever these were found, the discharges being computed by the most generally accepted formulæ.

Irregularities.

These experiments were not altogether satisfactory, from causes beyond our power to control. Frequently, while at work, we would discover the water to be rising or falling without apparent reason, and learn afterward that either the head-gate had been closed or more water turned in, or gates to lateral ditches opened or shut, causing a fluctuation in the main canal which seriously complicated the problem we were endeavoring to solve.

These elements of error must always exist unless extraordinary precautions be taken, and correct results can only be obtained from the average of a number of experiments. Rejecting the most doubtful cases, and accepting only those which appeared most satisfactory, the percentage of loss per mile, and the ratio of loss to the wetted perimeter and area of wetted surface, were computed and tabled.

Variations of loss from canals.

These results show that: (1) Aside from the variation in loss due to the different character of soils through which the canals pass, (2) the percentage of loss per mile increases as the size and capacity of the channels decrease; that (3) in large canals the percentage of loss is least, and in small ones greatest; that (4) the total loss increases very nearly in a direct ratio with the area of wetted surface.

Loss by percolation.

The depth of water, according to which the pressure at the bottom of the canals varies, may also have a direct effect upon the rate of percolation. The influence of depth of water, or its pressure, however, is very slight when compared to that of variation in character of soils.

Percentage of loss.

The percentage of loss per mile was found to vary from two per cent. to thirty-five per cent., and the entire loss due to percolation to vary from 0.0045 to 0.0298 cubic feet per second per 1,000 square feet of wetted surface.

Percolation in soils.

The mean rate of loss by percolation in sandy soils was 0.0184 cubic

feet per second per 1,000 square feet of wetted surface, the lowest being 0.0111, and the highest 0.0234. In sandy loam, and firm, compact alluvial soils, the mean rate of percolation was 0.0100 cubic feet per second per 1,000 square feet, the range being from 0.0045 to 0.0150.

Loss by evaporation.

The loss due to evaporation was taken at 0.0003 cubic feet per second per 1,000 square feet of water surface, that being about the average observed loss during the period over which the observations were taken.

Loss by percolation varies at different seasons.

The loss of water in canals by percolation diminishes year by year as the ground becomes settled. It is least in the winter and spring when the water is charged with sediment, and greatest in summer and fall when the water is clear. The clear water takes up and removes the thin film of sediment deposited on the bottom and sides of the canal, particularly after water has been shut off a few days. The heat bakes the sedimentary crust, which cracks, curls up, and is swept away when water is readmitted.

Curious example.

In a certain wheat field adjacent to the central branch of the Kern Island Canal, percolation first made its appearance on the surface in July last, eighteen months after the construction of the canal. In such quantity did the water pour out that there were standing pools over the surface of the ground, and for a considerable distance the soil was rendered so soft as to prevent the harvesting of the grain. The canal company were sufficiently accommodating to turn the water out of the branch line for a couple of weeks to allow the land to dry off and the grain to be harvested.

Extreme example.

The first year the Plunkett Canal was used on the Belle View Ranch, percolation was so excessive as to create large pools or lakes of water in all the adjacent low spots, damaging the crops. This ceased almost wholly the following year, and now lateral percolation is not noticeable to any extent. The soil is sandy and light. This has been a common experience on all the canals the first year of their use.

In the majority of cases no trace of lateral percolation can be discovered on the surface in the neighborhood of their course, while in a few the water lost from that source continues to saturate the adjoining lands to such a degree as to maintain standing pools in the low ground.

LOSS OF WATER BY EVAPORATION.

Evaporation.

The atmosphere of Kern Valley is excessively dry during the summer months, and evaporation is consequently considerable.

Experiments.

Experiments were begun in the latter part of June, and continued through July, August, and September, the three hottest months of the year, to determine approximately the amount of evaporation.

Results tabled.

The results are given in the following tables:

TABLE SHOWING RESULTS OF EXPERIMENTS ON EVAPORATION IN KERN COUNTY.

No. of observations	Date—1879.	Time of Observation.	Temperature. Water in pan	Temperature. Water outside of pan	Temperature. Air	Time of exposure between observations, in hours	Observed loss between observations, in feet	Average loss per hour, in feet	Average loss per twenty-four hours, in feet	Average loss, in cubic feet, per second per one thousand square feet	Average loss, in cubic feet, per second per square mile
	*Pan in Reeder Lake.**										
1	June 25th	6:25 p. m.	83°		92°	56½	0.040	0.00070	0.0168	0.00020	5.42
2	June 28th	7:50 p. m.	81°		90°	73½	0.068	0.00092	0.0222	0.00026	7.12
3	June 30th	5:00 p. m.	82°		79°	45	0.035	0.00078	0.0187	0.00022	6.04
4	July 5th	4:50 p. m.	87°		73°	120	0.096	0.00080	0.0192	0.000222	6.20
5	July 8th	5:00 p. m.	92°		77°	72	0.072	0.00100	0.0240	0.00028	† 7.74
	Pan in Panama Slough.‡										
1	July 9th	12:30 p. m.									
2	July 11th	6:20 p. m.	72°		76°	54	0.030	0.00056	0.01344	0.000160	4.34
3	July 21st	9:00 a. m.									
4	July 24th	6:50 p. m.			88°	82	0.037	0.00045	0.01080	0.000125	3.48
5	July 29th	6:15 p. m.	76°	71°	88°	119½	0.054	0.00045	0.01080	0.000125	3.48
6	August 5th	7:00 p. m.	79°	77°	92°						
7	August 13th	7:00 a. m.	72°	74°	76°						
8	August 20th	6:45 a. m.	64°	67°	68°	168	0.084	0.00050	0.01200	0.000139	3.87
	Pan in center of Kern Lake.§										
1	August 30th	10:40 a. m.	88°	86°	90°						
2	September 5th	11:30 a. m.	89°	81°	90°	145	0.105	0.000727	0.01745	0.000202	5.63
3	September 13th	12:30 p. m.	86°	86°	118°	193	0.096	0.000497	0.01192	0.000140	3.90
4	September 19th	12:05 p. m.	86°	86°	120°	144	0.150	0.001042	0.02500	0.000290	8.08
5	September 29th	12:10 p. m.	78°	78°	88°	240	0.180	0.000750	0.01800	0.000208	4.80

* The pans with which these experiments were made were of galvanized iron, two feet square and one foot deep. Reeder Lake is a narrow body of water, 12 to 15 feet deep, surrounded by large cottonwood trees and willows. The pan was placed in a shallow arm of the lake, fully exposed to the sun, but protected from the wind.

† Water fell leaving the pan at top six inches above water surface.

‡ In Panama Slough the pan was placed in running water 10 feet deep, showing a much lower temperature than Reeder Lake. It was fully exposed to the sun, but sheltered from the wind.

§ This pan was placed in the center of Kern Lake, about two miles from shore, in five feet of water. On September 5th, 13th, and 29th the wind was northwest, and on the 19th southwest.

TABLE SHOWING RESULTS OF EXPERIMENTS—Continued.

No. of observations	Date—1879.	Time of Observation.	Temperature. Water in pan	Temperature. Water outside of pan	Temperature. Air	Time of exposure between observations, in hours	Observed loss between observations, in feet	Average loss per hour, in feet	Average loss per twenty-four hours, in feet	Average loss, in cubic feet, per second per one thousand square feet	Average loss, in cubic feet, per second per square mile
	*Pan near shore of Kern Lake.**										
1	August 14th										
2	August 30th	10:40 a. m.	88°	86°	90°	384	0.480	0.00125	0.03000	0.000347	9.67
3	September 5th	11:10 a. m.	79°	83°	90°	144½	0.201	0.00139	0.03340	0.000386	9.31
4	September 13th	12:00 m.	88°	90°	118°	193	0.195	0.00101	0.02420	0.000281	7.81
5	September 19th	12:00 m.	81°	89°	120°	144	0.156	0.00108	0.02590	0.000300	8.36
6	September 29th	12:00 m.	76°	80°	88°	240	0.189	0.00079	0.01900	0.000220	6.13
	Pan in Kern River.†										
1	October 11th	4:00 p. m.	66°	64°	74°	216	0.104	0.00048	0.0116	0.000133	3.73
2	October 18th	4:00 p. m.	68°	66°	84°						
3	October 25th	4:00 p. m.	68°	66°	78°	168	0.052	0.00031	0.0074	0.000086	2.38
4	November 1st	4:00 p. m.	62°	61°	67°	168	0.052	0.00031	0.0074	0.000086	2.38
5	November 8th	4:00 p. m.	55°	55°	63°	168	0.045	0.00027	0.0064	0.000074	2.06
6	November 15th	4:00 p. m.	56°	56°	62°						
7	November 22d	4:00 p. m.	54°	54°	64°	168	0.030	0.00018	0.0043	0.000050	1.38
8	November 29th	4:00 p. m.	53°	53°	68°	168	0.030	0.00018	0.0043	0.000050	1.38
9	December 6th	4:00 p. m.	52°	52°	54°	168	0.030	0.00018	0.0043	0.000050	1.38
10	December 13th	4:00 p. m.	50°	50°	54°	168	0.030	0.00018	0.0043	0.000050	1.38
11	December 20th	4:00 p. m.	52°	52°	54°	168	0.030	0.00018	0.0043	0.000050	1.38

*This pan was placed in about two feet of water on the northeast side of lake. A gauge at side of pan indicated a loss of 0.4 from July 10th to July 29th; August 14th, 0.3 more; August 30th, 0.3 more; September 29th, 0.43 more; in all, from July 10th to September 29th, 1.43. From August 30th to September 29th—thirty days—pan in center of lake showed a loss of 0.531 foot; the pan on the shore of the lake, 0.741 foot, and the gauge 0.43, indicating a slight supply to the lake by percolation.

†This pan was placed in Kern River at Rio Bravo Ranch, three miles below Kern Cañon, freely exposed to sun and wind, but submerged in water to within two inches of its top.

TABLE SHOWING RESULTS OF EXPERIMENTS—Continued.

No. of observations	Date—1879.	Time of observation.	Temperature. Water in pan	Temperature. Water in lake	Temperature. Air	Time of exposure between observations, in hours	Observed loss between observations, in feet	Average loss per hour, in feet	Average loss per twenty-four hours, in feet	Average loss, in cubic feet, per second per one thousand square feet	Average loss, in cubic feet, per second per square mile
	*Pan on open ground.**										
1	October 3d	1:00 p. m.	68°	------	94°	30	0.037	0.00123	0.0292	0.000338	9.40
2	October 11th	4:00 p. m.	68°	------	74°	195	0.148	0.00075	0.0180	0.000209	5.80
3	October 18th	4:00 p. m.	80°	------	84°	168	0.071	0.00042	0.0101	0.000117	3.25
4	October 25th	4:00 p. m.	78°	------	78°	168	0.147	0.00087	0.0210	0.000243	6.76
5	November 1st	4:00 p. m.	70°	------	67°	168	0.148	0.00088	0.0211	0.000244	6.79
6	November 8th	4:00 p. m.	58°	------	63°	168	0.113	0.00067	0.0176	0.000203	3.46
7	November 15th	4:00 p. m.	65°	------	62°	168	0.030	0.00018	0.0043	0.000050	1.38
8	November 22d	4:00 p. m.	64°	------	64°	168	0.070	0.00042	0.0100	0.000116	3.22
9	November 29th	4:00 p. m.	62°	------	68°	168	0.052	0.00031	0.0074	0.000086	2.38
10	December 6th	4:00 p. m.	58°	------	54°	168	0.015	0.00009	0.0021	0.000024	0.68
11	December 13th	4:00 p. m.	55°	------	54°	168	0.037	0.00022	0.0053	0.000061	1.71
12	December 20th	4:00 p. m.	55°	------	54°	168	0.037	0.00022	0.0053	0.000061	1.71

* Pan placed on top of ground at Rio Bravo Ranch, free to the action of all elements, producing extreme evaporation.

The observations on evaporation at Rio Bravo Ranch were made by John Barker, Esq., who has shown a lively interest in all the work of this Department, and has rendered much valuable service. He is still continuing the observations on evaporation, as well as the daily record of gauge rods in the river.

CONCLUSIONS ON EVAPORATION.

From an examination of these tables, which, however, are only given as approximate, one must draw the conclusion that the greater portion of the volume of Kern River, after having been diverted into the canals and spread upon the lands, is ultimately evaporated either directly from the soil or from the surface of Kern and Buena Vista Lakes, which receives the drainage of three-fourths of the land at present irrigated.

During the month of September, the average depth evaporated from the surface of the lakes, as observed, was 0.636 feet, equal to a constant stream of 256.56 cubic feet per second, while the elevation of the surface was lowered in that time but 0.43 feet. There was, therefore, supplied to the lakes an average depth over their surface of 0.206 feet, equivalent to a constant stream of 83.09 cubic feet per second—all of which must have come from sub-surface drainage. The amount diverted by the canals of Kern Island in that period was an average of 131.81 cubic feet per second. Deducting from this discharge the quantity which probably found its way to the lakes, we have 48.72 cubic feet per second, presumed to be distributed over the area irrigated and retained in the soil or evaporated therefrom—an average of about one cubic foot per second for each square mile irrigated.

Evaporation from soils.

Experiments on the evaporation from saturated soils of different quality in water-tight boxes, gave a loss equal to 2.36 cubic feet per second per square mile on average loamy soils.

Experiments.

The specimens in the boxes were wet once in forty days. No opportunity was given for the water to soak away and drain off, as is the case with lands under irrigation; and the only value of the experiment is in the relation shown between the absorptiveness of the various soils. More extended and elaborate experiments of this nature, however, would be of interest and value.

The results obtained by the experiments on evaporation from soils are shown in the following table:

EXPERIMENTS ON EVAPORATION FROM SOILS IN KERN COUNTY, JULY AND AUGUST, 1879.

Nature of Soils.	Quantity absorbed in cubic feet per cubic foot of soil	Percentage	Quantity absorbed at subsequent trials, per cubic foot	Time between trials, in days	Loss in feet per square foot of surface	Loss in feet per day per square foot of surface	Equivalent loss per acre per day, in cubic feet	Equivalent loss per square mile per day, in cubic feet	Equivalent loss per second per square mile, in cubic feet	Depth dried out below surface between trials, in feet
No. 1—Light sandy loam	0.414	41.4	0.30	41	0.30	0.00732	318.86	204,070	2.36	0.30
No. 2—Strong alkali	0.375	37.5	0.208	41	0.15	0.00366	159.43	102,035	1.18	0.01
No. 3—Fine mica sand	0.42	42.0	0.42	41	0.42	0.01024	446.05	285,472	3.30	1.00
No. 4—Coarse river sand	0.60	60.0	0.60	41	0.60	0.01463	637.72	408,140	4.72	0.13
No. 5—Heavy brown loam from plain land, or "sagebrush soil"	0.36	36.	0.30	41	0.30	0.00732	318.86	204,070	2.36	0.25

REMARKS.—The boxes in which these experiments were made were of redwood, closely jointed, and water-tight. Numbers 1 and 2 were two feet square and one foot deep. Numbers 3, 4, and 5 were two feet by one foot, and one foot deep. All were buried in the ground to the tops of the boxes, the soil around them being moist. They were filled to saturation at each trial.

WASTE OF WATER.

The sources of an apparent waste of water in the irrigated section of Kern County are the following:

(1.) Waste due to *insufficient preparation* of the ground;

(2.) Waste due to the *duplication of canals*, and consequent unnecessary loss;

(3.) Waste due to *unskillful irrigation*.

Insufficient preparation.

(1.) The waste of water from a lack of sufficient preparation of the ground is common, and is due partially to the inexperience of irrigators, as well as to other causes—lack of means, excessive unevenness of surface in some localities, requiring considerable outlay to properly prepare it for rapid irrigation and the use of the minimum of water, the newness of the land, and the lack of experience as to the best means of preparation of the various classes of soils, etc.

Duplication of canals.

(2.) The waste due to the duplication of canals is the most serious fault of the Kern Valley system, and is the result of the ease and cheapness with which water may be diverted from the river at all points, owing to the rapid slope of the channel and of adjacent lands, and the low banks of the stream. It would seem that almost every individual who required water for irrigation, had, in the first instance, preferred cutting an independent ditch, rather than join in the construction of comprehensive and extensive works to cover the whole district. There are not less than thirty-two different canals and ditches with independent headworks, drawing water from the river, three-fourths of which might readily be dispensed with, and the lands they irrigate supplied with short laterals from the main canals. With the introduction of capital in the development of the irrigation system, and the increase of population, the tendency has been to construct larger and more comprehensive works, and to coöperate for mutual strength. The Stine Canal, for instance, has taken the place of a number of small ditches that formerly drew water from Old River, and the result has been a noticeable economy in water.

Unskillful Irrigation.

(3.) The waste due to unskillful irrigation, as well as that arising from carelessness in the application of water, is everywhere apparent. In many cases it is doubtless cheaper to use more water than will suffice than to devote the time and care necessary to distribute it evenly and economically; but it is a common fault to apply too much, which is to be deprecated, as it invariably injures the crops, and at the same time wastes water. The Chinese are particularly given to this fault, although they are skillful in the mechanical application of water.

Other causes of waste.

You have called my attention to other causes of waste, or loss of water, as applicable to other sections of the State, arising from:

1. Injudicious location, or faulty construction of canals.
2. Long distances between points irrigated.
3. Willful waste.
4. The use of water on wild lands without preparation of ground.

5. Diversion of water for stock purposes when needed for irrigation. I will discuss these in their order:

Injudicious location.

(1.) The canal system of Kern Valley is open to criticism, considered as a whole, for, although the individual works in themselves cannot be said to be injudiciously located, nor faultily constructed, could they have been built in conformity to a prearranged plan for the irrigation of the whole section of country which they command, many would have been otherwise located, or omitted altogether. Loss of water occurs less from faulty construction than from the extreme porosity of the soil. It is occasioned to some extent by the peculiar treatment rendered necessary by the excessive slope of the ground, a slope exceeding that which is possible to give the canals with safety in the friable soil of the country, and necessitating their construction in more nearly level reaches, with vertical falls at intervals of one half to three quarters of a mile, to reduce the velocity. At the upper end of these reaches the canal lies deep in the soil, and at the lower end is brought out more upon the surface with embankments. The general depth of water is necessarily increased much above what the canals would have were it safe to allow water to pass through them with the velocity due to the natural slope of the ground, and is greater than would be required on a canal having the same average grade without overfalls. The wetted perimeter is thus increased, and also the pressure under which water is forced out through the bottom and sides. The irregular motion of the water below the falls, commonly called "back-lash," prevents the natural puddling of the bottom and sides with sediment, and loss thereby results in porous soil. But as this method of treatment is indispensable, the loss thereby occasioned cannot be attributed to faulty construction in the canals, but to the peculiar topography of the country and the character of the soil which necessitates it.

Loss is occasioned by permitting the canals to get out of repair, and become choked with vegetable growth, etc., but this is not suffered to any great extent.

Loss in long canals.

(2.) There is little waste due to long distances between lands irrigated, except in cases of canals located along the lower portion of the river, where a large amount is absorbed in the thirsty bed of the stream before reaching them, so that in times of scarcity a great quantity requires to be turned down to supply a small demand.

Willful waste.

(3.) No instances of the willful waste of water came under my notice last season.

Irrigating wild lands.

(4.) But little irrigation of natural grasses is practiced in Kern County, and that only when water is not required elsewhere. The natural grasses which are considered worth irrigating do not grow on lands not naturally moist, and when irrigated would, therefore, require but little water.

Water for stock.

(5.) I know of no instances where water was diverted exclusively for stock purposes, when needed for irrigation elsewhere. After general irrigation is over, water is still allowed to run in all the canals for the use of stock, to save pumping; but I do not know that it has ever proven detrimental to the interests of irrigation.

Drainage and irrigation.

The natural slope of all the lands irrigated from Kern River is peculiarly favorable for drainage, but no special attention has been paid to the subject. The soil is so porous that it usually absorbs all that is applied in its irrigation, and appears to have more or less perfect sub-drainage towards the lakes, the impervious substrata having, it is thought, as great an inclination as the surface. The heavier soils—compact argillaceous loams—require drainage more than the sandy soils; but I know of no system adopted for that purpose.

The lack of drainage, to which such careful attention must be paid in other sections of the State, has not as yet been productive of results sufficiently apparent to demand general attention, but it is in itself an evil worthy of serious consideration, in view of its inevitable deleterious effect upon the health of the country and upon the productiveness of the soil. It may also become a source of waste of water. I noted a number of instances where standing pools, caused by percolation, might have been drained off and used to advantage in the irrigation of lower lands with little labor. Drainage is more perfect in the check levee system of irrigation than in any of the other methods, as in scraping up the material for the levees ditches are formed on either side, which are lower than the generality of the irrigated land inclosed by the levees, and serve as channels for the collection and drainage of the water from one compartment to another.

Conclusions on Waste of Water.

A consideration of the various sources of waste and loss of water that have been mentioned, leads to the conclusion that until those which are remediable are remedied the maximum duty of water will not be attained. Some are inevitable, and will continue for all time; others will diminish with the progress of years; and still others, due to defects in methods and management, will, it is to be hoped, be reduced to the minimum, as a greater experience is obtained and the necessity for greater economy becomes apparent.

APPROPRIATION OF WATER—WATER FILINGS AND RECORDS.

Indefinite claims.

The quantity of water claimed by the various canals of Kern County is so indefinitely expressed in the language of the recorded filings that it is almost impossible to determine its equivalent in cubic feet per second, or any other intelligible standard of measurement. The filings usually accord with the requirements of the law of 1873, in expressing the amount claimed in "inches measured under a 4-inch pressure." Presuming this expression, "under a 4-inch pressure," to mean the equivalent of the amount discharged through an inch square orifice in the bottom of a vessel in thin plate, used as a multiplier, the theoretical discharge by the old formula for orifices

of that nature—$D=a\sqrt{2gh}C$—would be 0.01995 cubic feet per second. In this formula, D represents the discharge in cubic feet per second; a, the area of orifice; g, the accelerating force of gravity $= 32,166$; h, the head or height from the center of gravity to surface of water (in this case four inches); C, a coefficient of contraction and friction, taken at 0.62.

Accepting this standard as the equivalent of the inch = 0.01995 cubic feet per second, the filings which are definitely expressed in "inches measured under a 4-inch pressure," of those canals whose rights are supposed to be in force, are equal to 10,701.5 cubic feet per second.

Latest filings.

The latest filings only, where a number have been made from time to time, have been regarded in making this estimate, and not the aggregate of all. Many of the canals have three or four filings, each either repeating the amount of the previous filing with some change as to point of location, etc., remedying the defects of former filings, and renewing the right, or claiming an additional amount. Claims that have apparently been abandoned have not been regarded.

Other filings are expressed in "feet," or "feet of flowing water," or "cubic feet," or "*cubit* feet." If we interpret these to mean a certain sectional area under a four-inch pressure, and apply the same standard multiplier as in the foregoing, the amount of this second class of claims is in the aggregate 660.78 cubic feet per second. Whether this interpretation be the correct one, however, is a matter solely of judgment.

There are a third class of canals, constructed prior to the passage of the law of 1873, whose rights are established by priority of appropriation, but for which there is no definite claim recorded. As, for instance, in the case of the Kern Island Canal, the articles of incorporation define a certain area or district (covering about 110,000 acres), which it is intended to irrigate, and for which water is claimed. A large portion of this district is now commanded and irrigated by other canals, so it would seem that the canal in question cannot properly claim all of the water required to irrigate the district named. Our only guidance in estimating the claims of this class of canals is probably, therefore, their maximum capacity as at present constructed.(?) On this basis we therefore have for our third class claims amounting to 505 cubic feet per second, although it is not known that these canals may not have more extended rights.

Total of claims.

The aggregate of all valid claims of these three classes, therefore, as nearly as they may be estimated and expressed in definite quantity, is approximately 11,890 cubic feet per second.

Amount diverted.

Our tables of canal discharges indicate that during the period from January to July (1879), inclusive, the average amount of water diverted by all the canals was 555.6 cubic feet per second, while the aggregate maximum capacity of those which received water is over 2,800 cubic feet per second.

The relation between the amount claimed and the amount diverted is shown by the following table:

TABLE

Showing the existing valid claims to the water of Kern River, and the relation between the amount of claims, the capacity of canals, and the amount diverted, as indicated by canal discharges during season of 1879, *January to July, inclusive.*

NAME OF CANAL.	Estimated equivalent in cubic feet per second of the amount of water claimed	Estimated maximum capacity, cubic feet per second	Mean discharge, January to July, inclusive, 1879, cubic feet per second	Greatest discharge at any time during season	Date of Greatest Discharge.
Beardsley	938.25	35	8.4	17.25	May 19.
McCord	99.75	45	17.5	34.12	March, May, and June.
Calloway	1,476.30	500	96.0	226.29	June 25.
McCaffrey	25.85	25	9.7	19.30	August 1 and 2.
Emery	39.90	20	3.2	10.55	June 6, 7; July 2, 3.
Jones & Tuckey	19.95	50	3.7	13.70	March 29.
Railroad	619.94	160	1.7	23.80	June 6.
Wible	100.54	300	7.2	53.77	June 6.
Goose Lake	1,795.50	1,000			
Pioneer	400.48	275	47.8	180.50	June 6.
Edwards	28.73	15			
James & Dixon	279.30	120	3.0	101.00	May 4.
Johnson	172.37	60	5.2	43.70	May 5 and 6.
May	79.80	10			
Dixon & Joice	124.67	17	2.4	17.00	June.
Dixon	68.95	17			
Kern Island	400.00	400	104.2	189.80	March 6.
South Fork	75.00	75	28.4	46.08	August 6.
Farmers'	287.28	150	45.8	100.90	May 3.
Castro	20.00	20	4.7	10.04	March 29.
Stine	1,116.59	250	96.1	219.34	April 7.
Baker & Noble	100.88	30	10.9	24.90	April 4.
Gates	100.88	18	3.2	11.30	May 1 and 2.
Buena Vista	279.30	140	22.9	48.60	April 30.
James	393.61	90	30.3	51.10	March 22.
Plunkett	100.88	20			
Meacham	29.92	15	2.8	11.68	May 3, 4, and 5.
Wilson	10.00	10	.5	3.16	June 7.
Henley	57.45	10			
Frazier	51.71	15			
Kern Valley Water Company	1,995.00	3,280			
Kern Valley, east side	598.50	90			
Totals	11,887.28	7,262			

IRRIGABLE LANDS AND APPROPRIATION OF WATER.

The following table is designed to show the relation between the irrigable lands in each of the irrigation districts of Kern Valley, and the appropriation of water as indicated by the aggregate maximum capacity of the canals of the several districts; the relation between the amount of water claimed and the total area of the districts (irrigable and non-irrigable); the area that might be irrigated by the water appropriated, and the water claimed under a duty of fifty, one hundred, and one hundred and fifty acres per second-foot respectively; and finally the relation which all these results bear to the water supply of 1879, as indicated by the mean discharge of the canals diverting all the water of the river, for a period of seven months:

TABLE

Showing the relation between irrigable and non-irrigable land, the amount of water claimed, and the irrigating capacity of constructed canals, etc.

District.	Total area of district, in acres	Area probably susceptible of profitable cultivation by irrigation	Amount of water appropriated, as indicated by the maximum capacity of canals	Amount of water claimed, in cubic feet, per second	Amount of lands irrigable by canals constructed (maximum capacity), in acres.			Amount of land irrigable by the total amount of water claimed, in acres.			Acres irrigable by total water diverted by canals, January to July, 1879, inclusive: under duty of 100 acres, per second-foot
					Under duty of 50 acres, per cubic foot per second	Under duty of 100 acres, per cubic foot per second	Under duty of 150 acres, per cubic foot per second	Under duty of 50 acres, per cubic foot per second	Under duty of 100 acres, per cubic foot per second	Under duty of 150 acres, per cubic foot per second	
No. 1. Between Old River and South Fork	80,000	75,000	895	1,898.87	44,750	89,500	134,250	94,943	189,886	284,829	27,920
No. 2. West of Old River and south of New River	64,000	50,000	348	1,124.63	17,400	34,800	52,200	56,231	112,462	168,693	7,060
No. 3. Between Goose Lake Slough and River	70,000	40,000	1,974	3,670.28	98,700	197,400	296,100	183,514	367,028	550,542	6,730
No. 4. Swamp Land Districts 121, 184, 185, and 208	103,000	90,000	3,370	2,593.50	168,500	337,000	455,500	129,675	259,350	389,025	
No. 5. Above Calloway Canal	60,000	50,000	80	1,038.00	4,000	8,000	12,000	51,900	113,800	155,700	2,590
No. 5. Below Calloway Canal	300,000	110,000	595	1,562.00	29,750	59,500	89,250	78,100	156,200	234,300	11,260
No. 6. East of Kern Island	70,000	60,000									
Totals	757,060	475,000	7,262	11,887.28	363,100	726,200	1,089,300				55,560

Remarks on foregoing Table.

"Irrigable" lands.

The area of "irrigable" lands is extremely difficult to define without a detailed examination, which it was impossible to give in the limited time at my command. In each district there is a certain area of lands probably not susceptible of profitable cultivation by irrigation, which may be called "non-irrigable." This area has been roughly approximated by the general information I was able to obtain, by observation and otherwise, of the character of the country.

Non-irrigable lands.

In District No. 5, for example, there exists a broad belt of strongly alkaline land on the west side adjoining the swamp lands, and covering two-thirds of its area, that is reported to be practicably worthless, and irredeemable at reasonable cost. In other districts the land estimated to be non-irrigable, is either unreclaimed swamp land, irregular sandy land, or land strongly impregnated with alkali, rendering it unsusceptible of profitable cultivation.

Extent of appropriation.

The column in the table of "amount of water appropriated," or maximum capacity of canals, is estimated from the data offered by our canal cross-sectional and other measurements and gaugings, and is believed to be generally within the limit of safe discharge, although possibly exceeding that limit in some cases.

Extent of claims.

The method of arriving at the probable amount of water claimed by recorded filings in cubic feet per second, is explained in detail elsewhere in this report. Fifty "inches under a four-inch pressure" were taken as about equivalent to one cubic foot per second. Where the filing was expressed in "feet, etc," it was assumed as meaning so many feet in area under the same pressure, and reduced by the same standard. In case of existing canals without definite claims recorded, the maximum capacity of the canals was taken as the claim.

Deductions from the table.

The table shows that in Districts One, Three, and Four, the existing canals have a capacity for the diversion of more than sufficient water to irrigate the entire irrigable area, with a very moderate duty of water, while Districts Two and Five are less amply provided—but nevertheless their canals have a capacity for the irrigation of a large percentage of the lands which are irrigable. For District No. 6, no canals have been constructed, although a portion of the district will ultimately be irrigated by extension of the canal system of District No. 1.

Relation of Water-Quantity diverted to the Amount used.

The past season being one of scarcity, the river discharging much less than in ordinary years, none of the canals carried water up to their maximum capacity, and no water was unnecessarily diverted. That it was all used advantageously and economically is another

question. However, no instances of the willful diversion of more than could be used came under my notice. When the supply is abundant the canals afford relief outlets to the river, and generally carry more than can possibly be used on the lands at present under cultivation, but their capacity, although in the aggregate sufficient for the supply of all the irrigable land in the valley, were it all under cultivation, is insufficient in some of the districts and more than sufficient in others, and this maximum capacity and appropriation of water are not wholly interchangeable; that is to say, the canals of one district cannot in all cases be extended upon and made to serve the lands of another district. To illustrate: The appropriation in District One, is in the aggregate, as shown by the foregoing table, 895 cubic feet per second, while the irrigable land in the district is about 75,000 acres. Under a duty of 150 acres per second-foot (which cannot be considered as unreasonably high, or unlikely to be attained) the appropriation would be sufficient to irrigate 134,250 acres, or nearly double the irrigable land of the district. In this case, however, it is possible to extend the canal system into District Six, to the east, by a projected branch of the Kern Island Canal; and indeed the district, for the irrigation of which the canal was originally organized, includes some 30,000 acres of District Six, designated in the description given in the articles of incorporation. The surplus appropriation will ultimately be used there. It is also possible to extend the system to the west upon District Number Two by branches of the Stine Canal across Old River, although District Two is already sufficiently supplied when water attains its maximum duty there; and indeed the enlargement of the canals to the full extent of their claims is contemplated in that district. District Three has a largely disproportionate appropriation to its area. The appropriation amounts to 1,974 cubic feet per second, sufficient under the assumed maximum duty of water to irrigate 296,100 acres, while the area of irrigable land in the district is but 40,000 acres. The canal system may, however, be extended upon District Four and the lower portion of District Five. It should be explained, moreover, that the appropriation by the Goose Lake Canal, which makes up a large share of the whole, is chiefly designed for drainage and the relief of the lower portion of Kern Island from overflow by diverting the surplus flood waters northward, and no use has yet been made of it for irrigation. The appropriation in District Number Four, as represented by the maximum capacity of the canals, is also disproportionate to the irrigable area, but these works were constructed for drainage and reclamation purposes as well as for irrigation, and having taken the place of the natural drainage outlet of Kern River toward Tulare Lake, are necessarily of large capacity to provide for the emergency of extreme floods.

The appropriation in the portion of District No. 5 above the Calloway Canal is as yet much too small for the irrigation of all the irrigable land in that sub-district, but the enlargement of the Beardsley Canal is contemplated, and if the appropriation is made equal to the full amount of the claim it will be more than sufficient. The irrigable portion of District 5 below the Calloway Canal is sufficiently provided for by the present appropriation, assuming the duty of water at 150 acres per cubic foot per second. District No. 6 is wholly unprovided for, except by the proposed extension of the Kern Island Canal.

MEASUREMENT AND SALE OF WATER.

No general system.

No well defined system of measurement has been introduced or used on any of the canals of Kern Valley, excepting that of the Kern Island Irrigating Canal Company, the only one from which water is sold.

Sale of water by the acre.

The first plan adopted on this canal, when the sale of water was begun in 1875, was to fix the charge at a certain price per acre irrigated, the amount being $1 50 for the season, taking no account of the number of irrigations applied or the number of crops irrigated. The disadvantage of this method became at once apparent, as there was no incentive to the farmer to use water economically, and *great waste ensued.* The following season this plan was abandoned and a system of flume measurement adopted, the standard being a square inch in area, with a velocity of two feet per second. The charge was one and one-quarter cents in spring and summer, and one cent in fall and winter, per inch.

Sale of water by volume.

The difficulty of delivering a uniform quantity by this method led to its abandonment, and in 1877 a system of measurement under a nominal four-inch pressure was begun. Gates were devised and erected at the heads of the distributing ditches, arranged with a movable bar four inches in height, placed about ten feet away from the gate, under which water was admitted. The amount of water required to be delivered was measured by the area of the orifice beneath the movable bar. The regulating gate was then raised to admit a sufficient quantity of water to keep the box filled to the top of the movable bar, the discharge below the bar being presumably under a four-inch pressure; for instance, in a gate two feet wide, to deliver 48 inches of water, the bar was raised two inches from the floor; to deliver 72 inches, the bar was raised three inches, etc.

The defects of this module are so glaring that, although it is still in use, it will doubtless be superseded by one far superior, which will be described. The chief defects are that the actual pressure, and consequently the discharge, varies materially with every variation in the height of the movable pressure bar. As the water in the canal outside the regulating gate may stand three or four feet deep above the bottom of the gate, it issues with great velocity through the gate to the measuring orifice, which is on the same plane. The discharge is therefore greater, as the velocity increases with any increase of depth of water in the canal. To illustrate the difference in discharge caused by the varying heights of the measuring or pressure bar, let us suppose that A. and B. have gates each four feet in width. A. purchases 96 inches of water, the orifice under the bar being two inches in height; and B. purchases 288 inches, the orifice being six inches in height, or three times that of A. B. would nominally receive three times the quantity purchased by A., but in reality would receive eighteen to twenty per cent. more than that proportion.

Another module.

Another module has been devised by F. H. Colton, Superintendent of the canal, which effects the object of a uniform discharge more

nearly than any appliance that has come under my notice on the canals of the State. It consists of a wooden box about thirty feet in length, placed in the lateral ditch, with its floor on a level or slightly below the grade of the main canal. The regulating gates at the end of the box next the canal are inclined backward at an angle of about 45°, the bottom of the gates resting on fixed planking, placed on the same incline up to a height of 20 inches above the floor. Twenty feet from these gates is placed the measuring bar, four inches in depth, with an orifice of six inches beneath it. The bottom of this orifice is two feet above the floor, or a few inches above the bottom of the regulating gates. The discharge from the orifice has consequently a free overfall, and is in no way retarded. The quantity of water discharged through the orifice is controlled by sliding gates, which meet in the center. The object of the incline of the regulating gates is to change the current of water admitted from a lateral direction to a nearly vertical drop into the box, while the orifice of final discharge being raised so high above the floor the boiling action of the water is stopped and it reaches the orifice comparatively quiet and without an initial impetus or velocity. The quantity delivered by this arrangement is different from that from the other form of measuring gates described, but its principal object being a uniformity of discharge, it effects a more satisfactory result, and any radical difference in discharge may be compensated by a change in price of water. It is constructed on good principles, and operates well. It bears some resemblance in form to the "*modulo magistrale*" of Milan. Its cost for a discharging capacity of 432 inches is about $75.

Cost of water.

At the present rates of water, if measured by this apparatus, the cost of flooding an acre one foot deep is but 27 cents for water alone; two feet deep, 54 cents; three feet deep, 81 cents, etc.

All outlet gates, of whatever character, are constructed by the canal company, at the expense of the irrigator.

Allotment of water.

The regulations of the canal company prescribe a certain allotment of water to irrigators, equivalent to twenty-four "inches" per day (twenty-four hours) per acre, for a period not exceeding fifteen days in each month. As this discharge, through the later measuring apparatus, for the period named would be sufficient to cover the land over nine feet in depth, the restriction is useless. No such amount would ever be used. Prior to April, 1878, the allotment was less than half this amount. Why it should have been changed is not clear.

Water rates.

The rates charged for water are as follows:

General Farming—April to November inclusive, 1½ cents per inch under a four-inch pressure, per irrigation of twenty-four hours; December to March inclusive, 1 cent per inch per twenty-four hours.

Market Gardens—For 12-inch stream and upwards for not less than half a month, 2 cents per inch per day of twenty-four hours; for 48-inch stream and upwards for one day or more, 2 cents per inch per day of twenty-four hours.

House Lots and Gardens—Twelve inches for one day of twelve hours, or 24 inches for one-half day of six hours, $1; 12 inches for

one night of twelve hours, 75 cents; 12 inches for one-half day of six hours, or 24 inches for three hours, 75 cents; 24 inches for one day of twelve hours, $1 50; 24 inches for one night, $1 25; 24 inches for one hour, 50 cents.

No statement in regard to the annual revenue of the canal could be obtained.

Distribution of water—coöperative plan.

On the other canals the division of water is one wholly dependent upon the judgment of the individual irrigators, or the person in charge of the works, without any special appliances to guide them.

Division of water by canal overseers.

On the larger canals, such as the Stine, Buena Vista, Pioneer, Calloway, and McCord, and occasionally the Farmers' and Beardsley, owned by a number of stockholders, a canal overseer (locally termed Zanjero) is employed, whose duty it is not only to maintain the supply of water in the canal and keep up repairs, etc., but to divide the water according to his best judgment, giving to each his proportionate share of the whole, and to enforce such general regulations as may be adopted by the stockholders. The cost of extraordinary repairs, annual sand clearances, etc., is met by assessments, the stockholders having the option of paying in cash or in labor at current rates.

EFFECTS OF IRRIGATION ON SOIL AND CLIMATE.

Effect on soils.

It is a noticeable fact that upon all the sandy soils at least, which form the principal area of the lands under cultivation, the effect of years of irrigation has been a marked increase in their fertility and an apparent change in their composition. Water and cultivation disintegrate the coarser particles of the soil, and the fertilizing elements contained become dissolved and prepared for plant growth. In filtering through the porous soil all the sediment and fertilizing matter contained by the water is detained and acts as a perpetual restorative. Rich fields, producing large annual crops, are to be seen in Kern Island, that were barren wastes of pure sand before irrigation reclaimed and fertilized them. A common method of treating the sandy hillocks and bare spots that occur at intervals, is to corral sheep upon them for a few weeks at a time. I have no data for establishing the rate of increase in the productive capacity of the land, but the general opinion seems to be that the average yield is greater, all other conditions being equal, as irrigation progresses.

Improvement in climate.

The change for the better in the climate of the country, since the general introduction of irrigation, has been as marked as the improvement in the soil. Old sloughs containing stagnant water have been purified by the introduction of fresh running water through them. Jungles of miasma-breeding willows have been cleared, swamps drained and dried out, and much decaying vegetation destroyed. Malarious fevers were formerly very prevalent, but have been much abated by these measures. How much the change of climate can be attributed to the influence of irrigation, if any, cannot be conjectured; but irrigation has certainly had no deleteri-

ous effects, or else they have been greatly overbalanced by the sanitary results of drainage and clearing.

TEMPERATURE OF WATER USED FOR IRRIGATION.

Observations made.

As the stimulating effect of water used for irrigation is largely dependent upon its temperature, the result of a series of observations on temperature during the past season may be of interest.

Temperature of the river water.

The lowest temperature of the river after issuing from the mouth of the cañon was during the remarkably cold weather in the early part of January, when it was recorded at 40° Fahrenheit. It rapidly rose to 60°, at which it remained the latter half of February, fluctuating during March between 50° and 60°, reaching 70° the latter part of April, ranging from 60° to 68° through May, from 70° to 75° through June, from 72° to 78° through July, 78° to 80° through August and September.

Temperature of water in canals.

On reaching the valley the temperature was increased, as the water was spread out over the broad shallow bed, and in July and August the water in the canals became as warm as 90° to 105° Fahr. The highest temperature of Kern Lake during August and September was 90°.

Temperature of water in artesian wells.

The water discharging from artesian wells, of which there are seven on Kern Island having a constant flow, maintains a uniform temperature of 71° Fahr., winter and summer. This remarkably high temperature renders the water valuable for winter irrigation particularly, but as yet no such use has been made of the few wells that have been bored. The wells are all located within a distance of six miles from the lakes, and outside of that belt all attempts at obtaining flowing water have thus far failed. The wells are from 250 to 460 feet in depth, and have a flow of 2,000 to 5,000 gals. per hour. One well is said to have a discharge of 10,000 gals. per hour. Their cost has been about $2,500 each, and it is reported that a number of additional contracts have been let at $1,600 per well, under guarantee of securing flowing water.

RESULTS OF IRRIGATION.

Cost of producing crops, yield, etc.

The cost of producing crops, by irrigation from Kern River, is differently estimated by the irrigators, and varies with the soil and the degree of skill manifested in the application of water.

Alfalfa.

Alfalfa has proved the most profitable crop that has been cultivated, yielding large crops, growing rapidly, and requiring but little attention. The plant has a long tap root which penetrates to a great depth; [alfalfa 5 months old, from seed, has been known to have a root from 3 to 4 feet long], and where surface water is not at a greater depth

than four to six feet it will thrive with one wetting in the season, while if the soil be retentive of moisture no irrigation is required. There are large areas that have become so moist by infiltration from canals that alfalfa would do well without irrigation after the first year. The following figures show the average cost per acre of producing alfalfa on the Belle View ranch:

Preparing land, plowing, harrowing, cross-harrowing, and pulverizing soil	$3 00
Seed, 20 lbs. per acre, @ 10 cts. per lb	2 00
Sowing	20
Labor of 3 irrigations, first year	50
Total	$5 70

Average yield, first year, in three cuttings, four tons; second year, six tons; subsequent years, ten to twelve tons. Value, $5 @ $10 per ton.

In 1875, a tract was sown with alfalfa and wheat together, the wheat yielding 40 bushels per acre, and the alfalfa three tons in two cuttings. But one irrigation was required to produce this result, and the case is an exceptional one.

Duty of an acre of alfalfa.

An acre of alfalfa is considered capable of supporting 5 head of horses or cattle, or 20 head of sheep, through the growing season—nine or ten months of the year.

Cereals—Wheat and barley.

The cost of preparing land, sowing, irrigating, and harvesting a crop of wheat is estimated at from $5 75 @ $8 25 per acre. The average yield of these cereals on the Belle View Ranch in 1878 was: Wheat, 27½ bushels; barley, 32 bushels per acre—averaged over an area of about two thousand acres. In exceptionably favorable spots 90 bushels of barley and 50 bushels of wheat per acre have been produced.

Corn.

The cost of a crop of corn averages as follows:

Irrigation prior to planting, per acre	$0 50
Plowing, harrowing, and planting, per acre	2 35
Cultivating, per acre	25
Suckering and hoeing, per acre	60
Irrigation per acre	50
Husking and hauling to granary, per acre	2 00
Shelling (for yield of 30 bushels), per acre	2 00
Total	$8 20

Average yield of shelled corn, 30@40 bushels per acre. The cost of cleaning the land of corn-stalks for another crop is 30@50 cents per acre.

Value of produce.

The value of these various crops is dependent upon the ruling market rates of produce elsewhere. The local market has always been good, and the products of agriculture have either been converted into beef, mutton, and pork, or have been consumed at home.

Production in 1878.

In 1878 the total quantity of wheat produced in Kern Valley, over and above the reserve for seed, was 1,550 tons, of which all but 50 tons was manufactured into flour at the Bakersfield Mills. In 1879 the yield has been estimated at 1,300 tons.

Irrigated wheat flour.

The experience of the millers is to the effect that irrigated wheat has a thicker skin, yielding more bran than that produced by dry farming, and that the flour is of a slightly darker color, but otherwise the quality is fully equal to any other wheat. Like all other California wheat it requires to be moistened before grinding.

Another effect of irrigation on cereals is noted in the toughening of the straw, making it more difficult to thresh and to separate the grain from the husk, but this is not a serious disadvantage.

STORAGE OF WATER.

The possibility of storing the surplus waters of Kern River in capacious reservoirs in the mountains during the flood seasons, holding them in reserve as a reinforcement to the supply in times of scarcity, is a subject already attracting the attention of the farmers of Kern Valley, and is one of great interest in its bearing upon the future development of irrigation.

Although in occasional seasons the stream does not afford more than is now required for supplying present demands, there are seasons in which floods are of frequent recurrence, either causing positive damage to the irrigation works and adjacent lands by overflow, or discharging a greater quantity of water than can be utilized, and resulting in great waste. The conservation of the waters and their distribution more evenly, from year to year, by holding back the surplus of flood years for use in dry seasons, as well as the regulation of the discharge through each season in conformity to the periods of greater demand, is therefore the paramount object for which storage reservoirs would be constructed.

The advisibility of building such reservoirs, aside from the prevention of damage by floods and the economizing of an element so precious in a rainless region, is simply a question of the money value of water. If one cubic foot of water per second flowing through the irrigating season, of say five months in the year, will irrigate 100 acres of cereal, or alfalfa, or corn, its value is represented by the net value of the crop, after deducting cost of production, interest on land, tools, etc., when applied to land which would produce no crop without irrigation. This net return varies of course with the market price of the products. Ordinarily cereals are expected to yield a net return of $5 @ $10 an acre, alfalfa $15 @ $20 per acre, and even these figures are small compared to the net profit occasionally realized, as for instance in the dry season of 1877, when alfalfa sold for $10 @ $15 per ton and yielded 6 to 8 tons per acre. But if we assume this net return to be not greater than $1 per acre per annum, the value of a cubic foot per second irrigating 100 acres would be $100 per annum, and would warrant an expenditure in saving or producing it of the principal yielding the $100 as interest, or say $1,000.

On the basis upon which water is sold on the Kern Island Canal a cubic foot per second flowing for five months is worth $75 @ $125.

A reservoir to store this quantity of water would cover an area of ten acres with an average depth of 30 feet.

With a reservoir of the same depth and an area of 1,000 acres (and on the headwaters of Kern River I am told there are sites for such), sufficient water would be stored to irrigate 10,000 acres, worth $10,000 per annum and paying interest at ten per cent. on an expenditure of $100,000. A reservoir site requiring that expenditure could not be considered a particularly favorable one.

In making this estimate due allowance has been made for probable loss by evaporation and percolation, by assuming a reasonably low duty for the water, and by placing its net value at a very small figure.

The subject is of sufficient importance to merit detailed examination and survey of the more important points likely to afford the desired conditions, *i. e.*, the maximum storage capacity attainable at the minimum expense, but with the limited time at my disposal the work could not have been attempted, even so far as a general reconnoissance.

OTHER SOURCES OF WATER SUPPLY.

There are several small streams flowing into Kern Valley on the east and south, which may be utilized for irrigation to a large extent if the waters were properly collected, and the supply saved and developed. The largest of these intermittent streams is Caliente Creek, which, however, is a torrent for a short period, and dry during the greater portion of the year. Tejon Creek and Tejon Pass Creek carry in ordinary seasons considerable volumes of water, until May or June each season. The latter on the third of March last discharged seven and a half cubic feet per second at the Tejon Reservation, where it is used for the irrigation of six acres of orchard and seventy-five acres of alfalfa and grain. A number of Tejon Indians have homes along the stream above the reservation, and use its waters for irrigating small patches of garden and grain, amounting to nearly fifty acres altogether. Tejon Creek has about the same volume as the former, and is also used to some extent by the Indians for the irrigation of their small gardens. Both these streams are clear beautiful mountain brooks, tumbling rapidly into the valley and disappearing in their rocky beds as they emerge from the foothills.

The Tecolla, Cañada de las Uvas, and the San Emidio Creeks, are the three other most important mountain streams that drain into the basin of Kern Valley from the south. They are used to some extent for irrigation.

The foothill lands which these streams can be made to supply are well adapted for fruit growing, and have a salubrious climate.

PRESENT CONDITION AND FUTURE PROSPECTS OF IRRIGATION IN KERN COUNTY.

More than three-fourths of all the land on Kern Island, in Districts Nos. 1 and 2, are owned by Haggin, Tevis & Carr. A considerable portion of District No. 5 is also owned by them. They have projected and are rapidly completing a comprehensive system of irrigation works, which will reclaim the otherwise barren and useless land, and con-

vert it into a fertile and habitable country. Their operations in the way of agricultural improvements are conducted on a scale that has no parallel in California, so far as my observation has extended. Their works are planned with intelligence and constructed with unusual economy—a rare thing in California irrigation works thus far.

Experimental farming.

Their plan of development of their lands seems to have been to thoroughly test the productiveness of the different grades of soil by the establishment of a number of large farms, conducted by experienced farmers under the general supervision of the owners, and the direct supervision of a general Superintendent. All manner of agricultural products have been tested on these farms, and at the same time especial attention has been given to stock growing, for the conversion of the farm products into a more profitable form—a wise system for a locality remote from the central markets of the world.

Leasing lands.

Aside from these large farms, smaller tracts, of 500 to 1,000 acres, have been selected, upon which have been erected comfortable dwelling houses, with stables, corrals, granaries, orchards, deep wells for the supply of pure water, etc. These have been leased to tenants on favorable terms, who are furnished with water for irrigation free of charge, from the general canal system. In District No. 1 fifteen of these establishments with two-story dwellings, and thirteen with one-story dwellings have been erected, the cost of improvements for each ranging from $1,500 to $3,000. In District No. 3 there are three such establishments, and in District No. 5 there are seventeen, of which 12 have two-story dwellings and five have one-story dwellings, the cost of each establishment averaging about $2,000.

Present operations.

This system of improvement is still in progress. New dwellings are being erected, and as fast as completed are occupied by tenants. After completing the full system of irrigation works the owners announce their intention of offering the lands for sale.

Terms of leases.

The terms of the leases are as follows: The tenants have rent and water free and the owners receive one-fourth of the crops. The leases run for five years, and, if the land requires clearing, the tenant has all he can make the first year free of rent. All ditches are paid for by the owners, but the tenant is required to prepare the land with necessary check levees at his own cost. At the expiration of the lease the tenant has privilege of purchase, in installments, at an agreed price. Credit is given to a reasonable amount at the company's store for supplies, seed, feed, etc., and the crop is purchased at the end of the season at the ruling market rates. The majority of tenants were very successful the past season, and raised large crops where water was properly applied.

Proprietor farmers.

Aside from the tenants of Haggin and Carr there are about 160 independent land owners and farmers in Kern Valley, most of whom are shareholders in some one of the irrigation canals. Many of them

have comfortable homes, and are fairly prosperous. As a rule, they have come into the country without other capital than their own hands and have had a struggle to get a start, in the face of difficulties which must always accompany a poor man in a new country where provision for irrigation must first be made, and experience in the art of irrigation must be slowly and expensively acquired.

Financial future of irrigation.

No fortunes have thus far been made in irrigated agriculture, but there has been a marked advance in the art, and a disinterested observer cannot but note the fact that with lands peculiarly favorable for irrigation, soil of undoubted fertility, and a climate stimulating the most prodigious growth of all agricultural products, the future of Kern Valley, under irrigation, must be one of progressive prosperity, brought about by an intelligent, industrious, and thrifty population.

Acknowledgments.

In closing a report which has already reached too great a length, but for which an absorbing interest in the subject must be my apology, I have to acknowledge the many courtesies extended me by those with whom I was thrown in contact in the course of my examinations in Kern County, and by whom I was greatly aided in the collection of the information contained in these pages. To name them individually would be almost to give a census of the irrigating population.

The results which have been given are necessarily but general approximations, and are as near the truth as it has been possible to arrive in the limited period of observation. Greater accuracy can only be attained by an extended series of observations, which it is to be hoped the importance of the subject will warrant.

Respectfully submitted.

JAMES D. SCHUYLER,
Assistant Engineer.

[APPENDIX C.]

REPORT ON IRRIGATION IN THE MUSSEL SLOUGH AND FRESNO DISTRICTS,

—IN—

TULARE AND FRESNO COUNTIES.

The following special paper is largely a rearrangement of a report by A. G. Warfield, Assistant Engineer, together with data compiled in this office:

CHAPTER I.

WATER SUPPLY;
IRRIGATION CANALS;
DIVERSION OF WATER.

DESCRIPTION OF KINGS RIVER.

Kings River, when we consider its size, position, and the area of country within the region of perpetual snow which it drains, as well as that on the plains which it is capable of supplying with water for irrigation, together with the fact that it is not navigable, nor a tributary to any of the rivers which are, may be justly regarded as one of the most important and valuable irrigation rivers in the State.

It has a drainage area of about 1,855 square miles in the Sierra Nevada Mountains and foothills above the "Upper Gauging Station," (which is located at the point where the river leaves the hill country and enters the Centerville bottoms) nearly half of which is situated within the snow belt.

It flows in a southwesterly direction from the mountains to Tulare Lake, and its general course is quite direct, with but few abrupt turns in its meanderings.

It has not a single perennial tributary from the foothills to Tulare Lake, a distance of about 62 miles; and the only stream of any note which empties into it is Watoke Creek, on the left, just above Smith's Ferry.

Character of channel.

Where it leaves the foothills all the water flows in a single well-defined channel, while in its passage through the "Centerville Bottoms" its waters are divided into several channels for a distance of about 14 miles. There it is all again collected and confined to a

single deep and tortuous channel, the bed of which is from 65 to 20 feet below the plains on either side.

Practically this portion of the river has no valley or bottom lands, the high bluffs encroaching generally upon the margin of the river. Here and there the bluffs recede, and the river is fringed with a narrow belt of alluvial deposit, covered with a scanty growth of oak trees and vines. This condition is maintained to the head of Cole Slough, a short distance below the San Joaquin Valley Railroad, where its waters are again divided, the greater portion passing northward down Cole Slough, and the rest along the old river channels, spreading into a delta-like swamp between Tulare Lake and the San Joaquin River.

Slope of river, high and low water elevations, etc.

The initial point from which the distances in the following table are measured is located at the beginning of the survey for a canal line south from Kings River, which is also the point where the Upper Gauging Station is established, and is near Brewster's cabin (township thirteen south, range twenty-four east, northeast quarter of southeast quarter of section eighteen.) The table shows the distance along Kings River from the initial point above described and located at the foothills, to the headgates of the most important canals, and other prominent points along the river, to Tulare Lake; the fall and grade per mile of the river between places mentioned in the table; also the elevation of the river banks, the low water of 1878, the high water of 1879, and that of 1867-8.

TABLE

Of distance, grade per mile, and elevation of low and high water along Kings River from the foothills to Tulare Lake.

Name of Place.	Total distances, in miles	Distance between places, in miles	Total fall between places, in feet—low water	Grade per mile, in feet—low water surface	Elevation of left bank, in feet	Elevation of low water, 1878	Elevation of right bank, in feet	Elevation of high water, 1879	Elevation of high water, 1867–8
From initial point, at the foothills					511	493.8	509	499.4	511.3
To headgate Kings River and Fresno Canal	2.16	2.16	32.3	14.95	475	461.5	471		
To headgate Fresno Canal	3.79	1.63	28.5	17.70	450	433.0	439		
To lower end of Centerville Bottoms	14.00	10.21	126.7	12.41	367	306.3	370		
To San Joaquin Valley Railroad Bridge	27.02	13.02	25.2	1.93	296	281.1	304	287.8	298.4
To headgate People's Canal	28.12	1.10	1.7	1.54	295	279.4	292		
To head of Cole's Slough	28.32	0.20	1.1	5.55	290	278.5	290		
To headgate Mussel Slough Canal	33.82	5.50	15.7	2.86	278	262.8	274		
To headgate Last Chance Canal	38.86	5.04	9.9	1.98	270	252.9	262		
To Kingston Bridge	41.37	2.51	5.6	2.24	259	247.3	258	253.0	
To end of survey (Meander Line No. 2)	45.18	3.81	8.6	2.26	250	238.7	250		
To head of Lower Kings River Canal	46.68	1.50	3.4	2.25		235.3			
To Southern Pacific Railroad Bridge	56.68	10.00	29.7	2.97	212	205.4	212	211.3	220.2
To Tulare Lake	62.00	5.32	0.0	0.0		205.4		207.4	
Totals and averages, etc.		62.00	288.4	4.65					

Description of the river channel.

At the upper gauging station all the water during the different stages flows in a single well defined trough or channel, with bottom and sides composed of large bowlders, intermixed with cobblestones, coarse gravel, and sand, in such proportions and manner as to present a comparatively even and regular surface, which offers but little resistance to the free flow of the water. This particular formation continues for several miles down the river, when the large bowlders disappear almost entirely, and the bottoms and sides of the numerous channels into which the river is divided are composed of large cobblestones, intermixed with coarse gravel and sand. This latter formation extends for several miles further down the river, to a point about midway between the upper and lower end of the Centerville bottoms, where the large cobblestones in turn disappear, and the river bed is composed of small cobbles, coarse gravel, and sand, which changes gradually, until the lower end of the Centerville bottoms is reached, where the material of which the bottom of the river channel is composed is almost exclusively coarse gravel and sand. From this point through to Tulare Lake, there are but few if any localities where anything but coarse gravel and sand is to be found in the river bottom, while the sides, particularly below the San Joaquin Valley Railroad Bridge, are composed of clay and sedimentary matter, intermixed with a gravelly alluvial deposit, which is unable to resist the abrading force of the current, especially in the bends and at high water, and is constantly being undermined and caving in.

High water periods.

Kings River, like all of the large rivers of the State heading high up in the Sierra Nevada Mountains, has two "high-water" periods in each year. The first usually occurs in December, after the rains have set in, continues through January, is known as the winter rise, and is caused principally by the rains. The second, which commences about the last of April or first of May, after the rains are over, and continues through June and part of July, is produced by the melting snow, and is of longer duration than the winter rise. The river generally keeps up between the two rises some one to two feet above its lowest stage.

After the second or spring rise, as it is usually called, the river gradually falls to the low-water stage, which it maintains through August, September, October, and a part of November, or until the winter rise sets in.

The time of the greatest demand for water for irrigation is fortunately during the winter and spring rises—when the river is capable of supplying, during ordinary years, all the water needed for the irrigation of lands at present prepared to receive it, and furnished with canals for its diversion and distribution.

During the past winter rise, which occurred in January, the river rose at the foothills 3.3 feet above the low-water mark of 1878, while at the San Joaquin Valley Railroad Bridge it rose 3.9 feet.

The river reached its highest stage for the past year in May, during the spring rise, which set in the latter part of March and continued through June, when it rose at the foothills 5.6 feet above the low-water mark of 1878; while at the San Joaquin Valley Railroad Bridge it rose 6.7 feet, at Kingston Bridge, 5.7 feet, and at the Southern Pacific Railroad Bridge, 5.9 feet.

The maximum discharge of the river during the winter rise was 3,425 cubic feet per second, while for the spring rise it was as high as 9,030 cubic feet per second, which was the greatest discharge for the year. The minimum discharge for the year ending October 31st, 1879, was 210, and the mean discharge 1,719 cubic feet per second.

Floods.

Since the settlement of the plains, and beginning of farming along Kings River, there have been two great floods—the first occurring during the winter of 1861–2, and the second during the winter of 1867–8—being occasioned in each instance by excessive rainfall during the winter months. During each flood the Centerville bottom was overflowed, and large quantities of driftwood deposited there. From the lower end of the Centerville bottom to a point a short distance above the San Joaquin Valley Railroad crossing, all the water during each of these floods was confined to the river channel. From the railroad crossing through to Tulare Lake, the country along the river on both sides was more or less flooded.

What is now known as Cole Slough, which carries a large portion of the waters of the river, was opened by the flood of 1861–2, and enlarged to its present size by that of 1867–8. The effect of diverting through this slough the greater portion of the water of the river during ordinary stages, and all during the period of low water, has been the gradual filling up of the old river channel with sand for several miles below the point of diversion, thereby reducing its carrying capacity, and at the same time producing an increase in the elevation of its flood line.

The flood of 1867–8 produced a rise in the river at the foothills of 17.5 feet above low water of 1878, while at the San Joaquin Valley Railroad Bridge it rose 17.3 feet, and at the Southern Pacific Railroad Bridge or Tulare Lake, 14.8 feet, as indicated by the most reliable high water marks of the flood that could be found.

DISCHARGE OF KINGS RIVER.

The following table shows the drainage area of Kings River; its maximum, minimum, and mean rate of discharge; the duration and amount in cubic feet per second per square mile of drainage area of each; the total amount of discharge in cubic feet; the depth in feet drained off the drainage area; and the area in acres that it would cover one foot deep during each of the four periods and for the year ending October 31st, 1879. The table also contains the totals and averages for the first and second irrigation periods, second and third periods, third and fourth periods, and the first and fourth periods. [The periods referred to are arbitrary divisions of the year into seasons of three months each, commencing with November, which have been made for convenience. A fuller explanation will be found in another chapter of this report, under the head of "Irrigation Periods."]

TABLE

Showing the amount of water supplied by Kings River during each of the four periods, and for the year ending October 31st, 1879.

NAME OF PERIODS.	Drainage area in square miles	Maximum rate of discharge.			Minimum rate of discharge.			Mean rate of discharge.		Total amount of discharge—cubic feet	Equivalent in depth and area.		REMARKS.
		Time in days	Amount in cubic feet per second	Amount in cubic feet per second per square mile	Time in days	Amount in cubic feet per second	Amount in cubic feet per second per square mile	Amount in cubic feet per second	Amount in cubic feet per second per square mile		Depth of water drained off in feet	Area of an equivalent one foot—acres	
First Period	1,855	1	3,425	1.84	23	210	0.11	321	0.17	2,549,307,200	0.049	58,524	November, December, and January.
Second Period	1,855	1	8,400	4.52	1	295	0.16	2,694	1.45	20,714,832,000	0.401	475,546	February, March, and April.
Third Period	1,855	2	9,030	4.87	1	635	0.34	3,557	1.92	28,275,134,400	0.547	649,107	May, June, and July.
Fourth Period	1,855	31	560	0.30	31	240	0.13	384	0.21	3,049,920,000	0.059	70,017	August, September, and October.
Total	1,855	2	9,030	4.868	23	210	0.113	1.731	0.933	54,589,193,600	1.056	1,253,195	
First Period, Second Period	1,855	1	8,400	4.52	23	210	0.11	1,488	0.80	23,264,139,200	0.45	534,070	
Second Period, Third Period	1,855	2	9,030	4.87	1	295	0.15	3,133	1.69	48,989,966,400	0.95	1,124,650	
Third Period, Fourth Period	1,855	2	9,030	4.87	31	240	0.13	1,970	1.06	31,325,054,400	0.61	719,124	
First Period, Fourth Period	1,855	31	560	0.30	28	210	0.11	352	0.19	5,599,227,200	0.11	128,541	

THE KINGS RIVER CANAL SYSTEM.

So far as definitely known, there are twenty-one ditches and canals which take or have taken water from Kings River for purposes of irrigation, as follows:

The Kings River and Fresno Canal takes water from the north bank of the river, near the foothills, and conducts it, for the most part, at right angles to the general direction of the river, to scattered farms upon the high plains north and east of the Town of Fresno. This canal, with branches, is about 22 miles in length.

The Fresno Canal and Irrigation Company's Canal takes water from the north bank of the river a mile below the head of the Kings River and Fresno Canal, and conducts most of it to the immediate neighborhood of the Town of Fresno, supplying several colony settlements. This canal, for a considerable portion of its length, occupies a natural channel, called at its upper end Mud Creek, and lower down, Fanshaw Creek. A branch ditch leads from the main canal, about four miles below its head, southerly (following the general direction of the river) to the neighborhood of Kingsburg, a distance of 16 miles. The total length of this canal and its main branches may be put at 63 miles.

The Centerville and Kingsburg Canal takes water about half a mile below the Fresno Canal and Irrigation Company's Canal, and conducts it down the ridge bordering the river to and below the Town of Kingsburg—a distance of 22 miles. The total length of this canal may be placed at 26 miles.

The Centerville and Sweem Ditches.—These are two small ditches, now consolidated with the other interests of the Fresno Canal and Irrigation Company, and which head near the larger canal of the company. They do not carry water except during high stages of the river. Their length may be placed at five miles, and their water claim is included in that mentioned for the company's larger ditch.

Morrow's, Kincaid's, Glenn's, and Barton's Ditches.—These are four small ditches which take or have taken water from the river during its high stages at points in the Centerville bottom lands, hereafter described. Their total length may be placed at nine miles.

The People's, Last Chance, Lower Kings River, Mussel Slough, Rhodes, and Sutherland's Slough Ditches.—These six canals take water from Kings River on the south side, below the crossing of the San Joaquin Valley Railroad, and conduct it to the Mussel Slough District, immediately adjacent to the river bottom, as hereafter described. Their total length, with main branches, is 116 miles.

The Emigrant Ditch takes water from Kings River on the north bank, and conducts it northward out on to the plains, where it is used in irrigation, about six miles from the river, near the settlement of Wild Flower. The total length of this canal is 15 miles.

The Vanderbilt, Harlan, Van Ness, Reed, and River Dale Ditches are very small farm ditches, taking water from the channels in the delta north of the Mussel Slough country and the river near the swamp in the trough of the valley. The total length of these ditches may be placed at 10 miles.

RECAPITULATION.

Ditches from Kings River.—Upper Kings River group, five in number, total length 116 miles; Centerville Bottom group, four in num-

ber, total length 9 miles; Mussel Slough group, six in number, total length 116 miles; Lower North Side group, one in number, total length 15 miles; Lower Delta group, five in number, total length 10 miles. Total number of ditches, 21; total length, 267 miles.

Remarks concerning the canals.

The three large ditches of the upper group, the five first mentioned of the Mussel Slough group, and that spoken of as the Lower North Side group, are the principal works, and their operation will be more particularly dwelt upon in what follows.

Nothing is known by the compiler hereof of the Grant and the Murphy's Slough Ditches, except that as per the data returned to this office. Water was used through them and irrigation effected as shown by the hydrological tables embodied in the last chapter of this Appendix.

In estimating the length of canals, it is believed that, in some instances, ditches which should be ranked as distributing ditches only have been taken as branch canals, and hence the mileage is probably excessive. It may be remarked that where no definite system exists, it is difficult to classify works of this kind.

Location and construction of canals.

The canals of this section, and as at present constructed, are rude and simple expedients, which attain their object, however, though less perfectly and at greater cost than if they had been constructed on sound principles, and in accordance with a pre-arranged plan or system for the judicious and economical distribution of water.

The channels are rough trenches generally following the undulations of the country, and are very badly located and leveled.

While the Mussel Slough country canal system yields the most favorable results as regards its powers of irrigation, this appears rather to be due to natural conditions than to skillful location, construction, and management.

With one or two notable exceptions all the irrigation that has been effected so far has been done with little or no system, and with a lavish waste of water that could never be permitted in any well regulated plan for the irrigation of the districts now under cultivation.

Light slopes of canals—the effect of.

Several of the canals in the Mussel Slough country have grades or falls so small that the velocity of the current is not sufficient to prevent the rapid growth of aquatic plants in the water-way—an evil of a serious nature in a tropical country, and, as is found by Indian and Italian experience, equally so in a temperate one. The carrying capacity of these canals is very materially reduced by this cause, and their usefulness correspondingly lessened.

Excessive slopes.

In several other instances the grades are so great as to cause serious damage to the channels by scouring and silting. The canals as a rule follow the general grade of the country, which, when found to be excessive, is modified or reduced by drops.

Bad effect of willows on canal banks.

One peculiar feature or condition of all the canals along Kings

River is, that in the course of a few years their borders become fringed or lined with a dense growth of willows, which rapidly attain a size sufficient to materially reduce the sectional dimensions of the channels, and thereby diminish their carrying capacity, and render the necessary repairs to them exceedingly tedious and expensive. In most instances the willows along the oldest canals form a complete shade or covering for the water, and thereby lessen, in a slight degree, the loss by evaporation.

Headgates.

All of these canals are provided with headgates, by which the quantity of water entering them is regulated. They are intended simply to prevent the flooding of the canals during the high stage of water in the river. The rule is to take into the canals, during the low-water stage, all that they can divert from the river, regardless of other interests, and during the period of an abundant supply, all that they can carry or that the irrigators may need.

Canal organizations—Mussel Slough country.

These canals have, in every instance, been laid out and constructed upon the coöperative plan by the irrigators themselves, who have formed companies for that purpose, each individual taking stock in the company in payment for work, and having the right to divert and use water from the canal in proportion to the number of shares he may have acquired by this means. The canals are managed in the same way, and the annual cost for repairs and superintendence is collected by assessment upon the stock, the aggregate of assessments representing the cost of water to each irrigator during the year.

A word of praise.

It is but just and proper in this connection to give merited praise to the energy and perseverance with which the people of this region, without experience in such matters, have grappled with the perplexing problem of irrigation, and have in a few years accomplished so much in the construction of canals, with scarcely any means but their teams and labor, for which they were to be repaid by the prospective value of their lands. Although the system they have developed is far from complete, and open to criticism from an engineering point of view, it must be borne in mind that when they began, irrigation was an experiment, the success of which was not altogether certain. They labored under many discouragements, but they now have the satisfaction of knowing that they have demonstrated the perfect adaptability of the soil and climate of their highly favored section for irrigation.

THE CAPACITY OF THE CANALS.

The following table shows the total estimated capacity, also the total amount of water in cubic feet per second claimed by all the canals in the Mussel Slough country, as well as those north of Kings River, which receive their supply from it, and are worthy of special mention; also the number of acres that could be irrigated by them, based upon their estimated capacity, and the amount claimed, assuming a duty of 50, 100, and 150 acres per cubic foot per second in each case.

TABLE

Showing the aggregate capacity of the canals from Kings River, with reference to the irrigation of the adjacent plains.

Name of District.	Total area of district, in acres	Area probably susceptible of profitable cultivation by irrigation	Amount of water appropriated, as indicated by the maximum capacity of canals	Amount of water claimed, in cubic feet, per second	Amount of land irrigable by canals constructed—maximum capacity.			Amount of land irrigable by the amount of water claimed (in acres).			Acres irrigable by total water diverted by canals, Jan. to July, 1879, inclusive; under duty of 100 acres per cubic foot per second
					Under a duty of 50 acres per cubic ft. per second	Under a duty of 100 acres per cubic ft. per second	Under a duty of 150 acres per cubic ft. per second	Under a duty of 50 acres per cubic ft. per second	Under a duty of 100 acres per cubic ft. per second	Under a duty of 150 acres per cubic ft. per second	
Mussel Slough	155,000	115,000	1,040	3,755	52,000	104,000	156,000	187,750	375,500	563,250	44,300
Between Kings River and San Joaquin River	-------	-------	980	3,932	49,000	98,000	147,000	196,600	393,200	589,800	44,370

It will be seen by reference to the tables, that in the case of the Mussel Slough country, where the total number of acres in the whole district is given, as well as the number of acres estimated as highly suitable for irrigation, that the amount of water the canals are capable of carrying in their present condition is sufficient to irrigate 104,000 acres, allowing a duty of 100 acres per cubic foot per second, which is thought to be a fair duty for this district under present circumstances or conditions of works and degree of care in irrigation. The table also shows that the amount claimed far exceeds the capacity of the canals, and that with the low duty of 50 acres per cubic foot per second it will irrigate a greater number of acres than there are in the whole of the Mussel Slough country.

The four canals leading out from Kings River on the north, have an aggregate estimated capacity of 980, and claim 3,932 cubic feet per second—an amount four times greater than they are capable of carrying.

COST OF IRRIGATION WORKS.

The cost of the People's Ditch, as shown by the following table, was $3,125 00 per mile, which is about twice the average cost of all the rest of the canals in the Mussel Slough country. This is owing to the fact that the canal is provided with two large headgates, one at the river through which the water is diverted, and another about two miles below at the beginning of a long, deep, and expensive cut, through which the water is conducted out on the plains and brought to the surface for irrigation.

Another reason is, that the main canal and its branches do not occupy natural watercourses, as is the case with several of the other canals, but are all well constructed artificial channels which are supplied with numerous, well arranged, and substantially built drops, by which the fall of the country is overcome and the expense of the canal thereby increased.

Still another cause of its increased cost is found in the necessary yearly repairs to the dam in Kings River.

This is in many important respects the best located canal in the Mussel Slough country, and certainly occupies a position from which a larger territory can be irrigated than from any other canal in the district.

The estimated capacity of the Mussel Slough Canal is not founded upon as satisfactory data as that used in the case of the others.

The maximum discharge of this canal, near the headgate at the river, as shown by the observations and measurements of the past year, was 600 cubic feet per second, which is believed to be a far greater amount than the main canal is capable of carrying within its banks, or than its branches can possibly accommodate, for which reason its estimated maximum capacity is given in the table at 350 cubic feet per second—an amount which it can carry and distribute.

COST OF IRRIGATION WORKS.

This table refers to the canals in the Mussel Slough country.

Name of Canals.	Length of main canals and branches in miles	Cost of main canals and branches—approximated	Cost of main canals and branches per mile	Period of flow, in days	Mean discharge for the period of flow in cubic feet per second—1879	Estimated maximum capacity of canals in cubic feet per second	Amount of water claimed in cubic feet per second	Total number of acres of irrigable land	Number of acres irrigated in 1879	Number of acres irrigated per cubic foot per second for period of flow of the canals	Cost of main canal and branches per acre irrigated in 1879	Cost of main canal and branches per acre irrigated, based upon their estimated capacity. Under a duty of 50 acres per cubic foot per second	Under a duty of 100 acres per cubic foot per second	Under a duty of 150 acres per cubic foot per second
People's	32	$100,000	$3,125 00	206	126	280	1,152	--------	13,340	106	$7 50	$7 15	$3 57	$2 38
Mussel Slough	20	30,000	1,500 00	137	153	350	864	--------	3,846	25	7 80	1 70	0 85	0 57
Last Chance	31	50,000	1,612 90	207	121	185	288	--------	13,040	108	3 91	5 40	2 70	1 80
Lower Kings River	20	30,000	1,500 00	365	36	50	315	--------	6,084	169	4 93	12 00	6 00	4 00
Rhodes'	10	10,000	1,000 00	153	18	25	44	--------	1,600	88	6 25	8 00	4 00	2 66
Totals and averages	113	$220,000	$1,947 00	------	454	890	2,663	--------	37,910	84	$5 80	$4 94	$2 47	$1 65
Settlers	23	$30,000	$1,304 35	60	30	75	432	--------	1,750	58	$17 14	$8 00	$4 00	$2 67
Lake Side	32	50,000	1,562 50	60	30	75	660	--------	1,400	47	35 72	13 33	6 66	4 44
Totals and averages	55	$80,000	$1,454 50	------	60	150	1,092	--------	3,150	53	$25 39	$10 66	$5 33	$3 55
Grand totals and averages	168	$300,000	$1,785 71	------	514	1,040	3,755	115,000	41,060	80	$7 30	$5 76	$2 88	$1 92

COST OF IRRIGATION WORKS.

This table refers to the canals leading out from Kings River to the north.

Name of Canals.	Length of main canals and branches in miles	Cost of main canals and branches—approximated	Cost of main canals and branches per mile	Period of flow, in days	Mean discharge for the period of flow in cubic feet per second	Estimated maximum capacity of canals in cubic feet per second	Amount of water claimed in cubic feet per second	Total number of acres of irrigable land	Number of acres irrigated in 1879	Number of acres irrigated per cubic foot per second for period of flow of the canals	Cost of main canal and branches per acre irrigated in 1879	Cost of main canal and branches per acre irrigated, based upon their estimated capacity. Under a duty of 50 acres per cubic foot per second	Under a duty of 100 acres per cubic foot per second	Under a duty of 150 acres per cubic foot per second
Kings River and Fresno	22	$62,000	$2,818 18	273	66.4	200	852	--------	1,500	22.5	$41 33	$6 20	$3 10	$2 07
Fresno				365	261.4	500	2,700	--------	8,500	32.5				
Centerville and Kingsburg	26	50,000	1,923 07	365	116.7	200	300	--------	3,000	25.6	16 66	5 00	2 50	1 67
Emigrants	15	23,000	1,533 33	189	42.5	80	80	--------	5,800	136.4	3 96	5 75	2 87	1 92
Totals and averages	63	$135,000	$2,142 85	------	487	980	3,932	--------	18,800	45.6	7.18	--------	--------	--------

DIVERSION OF WATER.

The table of discharge, calculated for the Upper Gauging Station, where the river leaves the foothills, and above all the canals which divert its waters for irrigation, shows that from January 31st to July 31st, 1879—a period of 181 days—the river discharged 48,989,966,400 cubic feet, or a mean of 3,132.3 cubic feet per second, or 1.69 cubic feet per second per square mile of drainage area.

Diversion of water, February to July, 1879, *inclusive.*

During the same period all the canals supplied by the river diverted in the aggregate 24,770,424,900 cubic feet, or 50.5 per cent. of the amount discharged by the river, of which 16,543,790,600 cubic feet, or 66.8 per cent. of the amount diverted was actually used for irrigation, showing a loss between the points of diversion and the irrigated districts of 8,226,634,300 cubic feet.

This shows that the canals at the points of diversion in some instances have a greater capacity to appropriate than they have for conducting, the amount diverted, to the fields for irrigation.

This is notably the case with the Mussel Slough Ditch and the Lower Kings River Water Ditch.

Relation of supply to amount diverted.

The following table shows the amount supplied by Kings River and the amount diverted by the canals during each of the four periods of the year ending October 31st, 1879:

First Period—Kings River	2,549,307,200
" " —Canals, 81 per cent.	2,072,364,000
" " —Amount left in river, 19 per cent.	476,943,200
Second Period—Kings River	20,714,832,000
" " —Canals, 47 per cent.	9,700,154,900
" " —Amount left in river, 53 per cent.	11,014,677,100
Third Period—Kings River	28,275,134,400
" " —Canals, 53 per cent.	15,070,270,000
" " —Amount left in river, 47 per cent.	13,204,864,400
Fourth Period—Kings River	3,049,920,000
" " —Canals, 75 per cent.	2,284,974,400
" " —Amount left in river, 25 per cent.	764,945,600
Total Kings River	54,589,193,600
Total canals, 53 per cent.	29,127,763,300
Total left in river, 47 per cent.	25,461,430,300
Total discharged into Tulare Lake, 25 per cent.	13,791,413,600
Total lost by evaporation and percolation, 21 per cent.	11,670,016,700

Relation of supply to amount used.

The following table shows the amount supplied by Kings River and the amount used for irrigation during the four periods of the year ending October 31st, 1879:

First Period—Kings River	2,549,307,200
" " —Canals, 73 per cent.	1,861,488,000
" " —Left in river, 27 per cent.	687,819,200
Second Period—Kings River	20,714,832,000
" " —Canals, 30 per cent.	6,286,187,000
" " —Left in river, 70 per cent.	14,428,645,000
Third Period—Kings River	28,275,134,400
" " —Canals, 37 per cent.	10,257,603,600
" " —Left in river, 63 per cent.	18,017,530,800

Fourth Period—Kings River	3,049,920,000
" " —Canals, 75 per cent.	2,284,974,400
" " —Left in river, 25 per cent.	764,945,600
Total Kings River	54,589,193,600
Total canals, 38 per cent.	20,690,253,000
Total left in river, 62 per cent.	33,898,940,600

Relation between amount diverted and that used.

The following table shows the amount diverted from Kings River, and amount used for irrigation during each of the four periods of the year ending October 31st, 1879:

First Period—Amount diverted	2,072,364,000
" " —Amount applied for irrigation, 82 per cent.	1,861,488,000
" " —Lost, 18 per cent.	210,876,000
Second Period—Amount diverted	9,700,154,900
" " —Amount applied for irrigation, 65 per cent.	6,286,187,000
" " —Lost, 35 per cent.	3,413,967,900
Third Period—Amount diverted	15,070,270,000
" " —Amount applied for irrigation, 67 per cent.	10,257,603,600
" " —Lost, 33 per cent.	4,812,666,400
Fourth Period—Amount diverted	2,284,974,400
" " —Amount applied for irrigation	2,284,974,400
" " —Lost	
One Year—Amount diverted	29,127,763,300
One Year—Amount applied for irrigation, 71 per cent.	20,690,253,000
Lost, 29 per cent.	8,437,380,300

Surplus waters of Kings River—Discharge into Tulare Lake.

The following table shows the amount left in Kings River, after deducting the amount diverted, also the amount discharged into Tulare Lake, and the amounts lost by evaporation and percolation, during each of the four periods of the year ending October 31st, 1879:

First Period—Amount left in river	476,943,200
" " —Amount discharged into Tulare Lake, 33 per cent.	158,976,000
" " —Amount lost by evaporation and percolation, 67 per cent.	317,967,200
Second Period—Amount left in river	11,014,677,100
" " —Amount discharged into Tulare Lake, 39 per cent.	4,390,243,200
" " —Amount lost by evaporation and percolation, 61 per cent.	6,624,433,900
Third Period—Amount left in river	13,204,864,400
" " —Amount discharged into Tulare Lake, 69 per cent.	9,083,318,400
" " —Amount lost by evaporation and percolation, 31 per cent.	4,121,546,000
Fourth Period—Amount left in river	765,045,600
" " —Amount discharged into Tulare Lake, 21 per cent.	158,976,000
" " —Amount lost by evaporation and percolation, 79 per cent.	606,069,600
Total amount left in river	25,461,430,300
Total amount discharged into Tulare Lake, 54 per cent.	13,791,413,600
Total amount lost by evaporation and percolation, 46 per cent.	11,670,016,700

Summary of the four preceding tables.

First Period—Supplied by Kings River	2,549,307,200
" " —Amount diverted from Kings River, 81 per cent.	2,072,364,000
" " —Amount used for irrigation, 73 per cent.	1,861,488,000
" " —Amount discharged into Tulare Lake, 6 per cent.	158,976,000
" " —Amount lost by evaporation., 1 per cent.	26,946,432
" " —Amount lost by percolation, 11 per cent.	291,020,768
Second Period—Supplied by Kings River	20,714,832,000
" " —Amount diverted from Kings River, 47 per cent.	9,700,154,900
" " —Amount used for irrigation, 30 per cent.	6,286,187,000
" " —Amount discharged into Tulare Lake, 21 per cent.	4,390,243,200
" " —Amount lost by evaporation, 0.4 per cent.	82,432,512
" " —Amount lost by percolation, 32 per cent.	6,542,001,388

Third Period—Supplied by Kings River	28,275,134,400
" " —Amount diverted from Kings River, 53 per cent.	15,070,270,000
" " —Amount used for irrigation, 37 per cent.	10,257,603,600
" " —Amount discharged into Tulare Lake, 32 per cent.	9,083,318,400
" " —Amount lost by evaporation, 1 per cent.	240,292,224
" " —Amount lost by percolation, 14 per cent.	3,881,253,776
Fourth Period—Supplied by Kings River	3,049,920,000
" " —Amount diverted from Kings River, 75 per cent.	2,284,974,400
" " —Amount used for irrigation, 75 per cent.	2,284,974,400
" " —Amount discharged into Tulare Lake, 5 per cent.	158,976,000
" " —Amount lost by evaporation, 4.05 per cent.	138,150,144
" " —Amount lost by percolation, 15 per cent.	467,919,456
Total supplied by Kings River	54,589,193,600
Total amount diverted from Kings River, 53 per cent.	29,127,763,300
Total amount used for irrigation, 38 per cent.	20,690,253,000
Total amount discharged into Tulare Lake, 25 per cent.	13,791,513,600
Total amount lost by evaporation, 1 per cent.	487,821,312
Total amouut lost by percolation, 20 per cent.	11,182,195,388

Diversion of water for the year ending October 31st, 1879.

Of the 54,589,192,600 cubic feet of water supplied by Kings River during the year ending October 31st, 1879, 29,127,633,300 cubic feet, or about 53 per cent., was diverted for irrigation, of which there was only 20,690,253,000 cubic feet, or about 71 per cent. of the amount diverted, or about 38 per cent. of the water supplied by the river, actually applied to the lands under cultivation by irrigation.

Deducting the whole amount diverted from the amount supplied, we have 25,461,559,300 cubic feet, or 45 per cent. of the whole discharge, remaining in the river, of which 13,791,513,600 cubic feet, or 54.2 per cent of the amount remaining (or 25 per cent. of the whole amount supplied by the river), was discharged into Tulare Lake, leaving 11,670,045,700 cubic feet to be accounted for by evaporation, percolation, and loss by overflow in the Centerville Bottom and the overflowed basin along the river below the San Joaquin Valley Railroad.

Of the 11,670,045,700 cubic feet thus to be accounted for, it is estimated that during the year not less than 487,821,412 cubic feet, or 4.2 per cent., was lost by evaporation alone from the main channel of the river from the foothills to Tulare Lake, a distance of 62 miles, leaving 11,182,195,288 cubic feet lost by percolation and overflow into the Centerville Bottom and along the river below the railroad.

POINTS OF DIVERSION.

The Kings River survey, which extends from the foothills to a point about four miles below Kingston, as well as the survey of canal lines south from the river, and the levels and examinations made on the north side of the river, all go to show that it is a river from which it is easy to divert water for irrigation—in which respect it is equal if not superior to any of the other large rivers in the southern portion of the San Joaquin Valley.

There are three canals leading out from the right bank of the river, near the foothills, which supply water for irrigation in the neighborhood of Kingsburg and Fresno. All the others of any importance are located below the San Joaquin Valley Railroad Bridge, principally upon the left bank. Those whose headgates are located near the foothills are perennial in their flow, while those below the railroad bridge are intermittent.

RELATION OF AMOUNT DIVERTED TO AMOUNT USED FOR IRRIGATION.

Kings River supplied during the year ending November 30th, 1879, 54,589,193,600 cubic feet of water. Of this amount there was diverted from the river, through the canals and sloughs used for conducting water to the irrigated districts, 29,127,633,000 cubic feet, while only 20,690,253,000 cubic feet were actually applied to the land under cultivation by irrigation, which shows a loss of 8,437,380,000 cubic feet between the several points of diversion and the lands to which the water was being conducted for use. This does not include the loss by evaporation, etc., in the main channel.

A large portion of this loss is due to Murphy's Slough on the right side, and to the Lower Kings River Canal on the left side of the river.

By far the greatest loss is found in the case of the latter. There is no headgate near the river by which to control the amount entering the canal. The headgate which does regulate the amount is situated several miles from the river.

The total amount conducted by this canal upon the fields for use, as shown by the tables, was 1,142,208,500 cubic feet, while the total diverted from the river during the same period was 8,507,868,000 cubic feet, or a loss of 7,365,660,000 cubic feet between the river and headgate which regulates the flow into the canal.

As there are no other canals along the river below this point which take their supply of water directly from the river, this loss from the main channel is not to be considered as affecting the interest of any other claimant or canal company. There is no doubt but that a large portion of the 7,365,660,000 cubic feet is conducted by an underground seepage or drainage into the very district commanded by the canal by which the same was diverted from the river in the first instance. This is one important factor, no doubt, in the high duty of water along the line of this canal; the table shows that each cubic foot per second, for 365 days, irrigated about 167.83 acres—being the greatest number irrigated by a cubic foot per second in the Mussel Slough country.

CHAPTER II.

IRRIGATION DISTRICTS—EXTENT, COST, PERIODS, AND EFFECTS OF IRRIGATION—DRAINAGE—WORKS, PRACTICE, AND RESULTS OF IRRIGATION—MEASUREMENT OF WATER.

The Irrigation Districts.

Description of plains.

The general topographical features and characteristics of the plains between the foothills and Fresno Slough on the north, and Tulare Lake on the south of Kings River, are such as to warrant the opinion that they are possibly as well if not better favored than any other equally extensive region of country to be met with along the large rivers in the upper end of the San Joaquin Valley, in their soils and subsoils, uniformity of surface and slope, and abundance of water supply.

The soil of a large portion of the upper part of the plains to the north of the river is a granitic, sandy alluvium, specially adapted to farming by irrigation.

Minor streams.

All the small streams heading in the foothills between Kings River and the San Joaquin on the north, and the Kaweah on the south, which are not tributaries to either of these rivers, extend out into the plains for several miles with well-defined channels, which gradually become less clearly-defined, and disappear altogether at points about midway between the foothills and Fresno Slough on the north, and the Mussel Slough country on the south, beyond which points the water never extends except in seasons of excessive rainfall, such as occurred during the winters of 1861–2 and 1867–8.

These streams maintain directions generally parallel with each other and the large rivers on either side; but being intermittent, are not of sufficient importance to render them available, *unaided by reservoirs*, as sources of water supply for irrigating any portion of the plains through which they pass; nor are they of sufficient magnitude to interfere in any way with the location and construction of canals either along or across their courses.

Centerville Bottom.

The Centerville Bottom, the general surface of which is elevated but a few feet above the ordinary stage of water in the numerous channels of Kings River by which it is traversed, contains 16,700 acres, or 26.1 square miles, all of which, except that under cultivation, amounting to 1,500 or 2,000 acres, is covered with a dense growth of valuable timber, comprising oaks, willows, and cottonwood—the latter being found only along the lower portion of the bottom.

This bottom is from 10 feet at the upper end to 50 feet at the lower end, beneath the general surface of the plains surrounding it. The second bottom or low-land on the left side of the river, which is from 10 to 20 feet higher than the Centerville Bottoms, and from 20 to 35 feet below the level of the plains extending southward, comprising all the territory through which the Kincaid Ditch runs, contains 6,640 acres, or 10.4 square miles, the greater portion of which is valuable agricultural land. This bottom has never been overflowed during any of the great floods.

The overflowed or swamp lands in the delta of, and along Kings River south of Kingston, is roughly estimated at about 45 square miles, or about 28,800 acres.

Irrigation North of Kings River.

This irrigation is conducted principally in the neighborhood of the towns of Fresno, Centerville, and Kingsburg, in Fresno County.

Duty of water.

The Kings River and Fresno, the Fresno, and the Centerville and Kingsburg Canals diverted in the aggregate 10,276,347,200 cubic feet (equal to a mean discharge of 329 cubic feet per second) of water from Kings River during the year ending October 31st, 1879, and irrigated 13,000 acres, which, if the amount of water diverted had been uniformly distributed, would have been covered to the depth of

18.16 feet, an amount equivalent to one foot in depth over 236,080 acres, while each cubic foot per second irrigated only 39.5 acres—a very low duty for that region of country.

The canals conduct the water diverted by them from the river for 10 or 15 miles respectively, before any great amount is actually applied to the lands under cultivation.

The use of water.

The special gaugings made along two of these canals last July, for the purpose of determining approximately the loss by evaporation and percolation, show that about 17 per cent. of the total amount diverted is lost before it reaches the regions under cultivation along the respective canals, while about 30 per cent of the average quantity conducted through them from their headgates to the principal points of diversion through the distributing ditches, is lost.

Therefore, assuming that 83 per cent. of the total amount diverted by these canals, which is equal to 8,529,368,176 cubic feet, or a mean discharge of 273 cubic feet per second, was actually used for irrigation, it would, if evenly distributed over the 13,000 acres irrigated, cover them 15.07 feet, equivalent to an area of 195,946 acres covered one foot in depth; while one cubic foot per second would irrigate about 48 acres, or, in like manner, assuming that 70 per cent. of the total amount diverted was used in irrigation, then each cubic foot will have served 57 acres, which represents the probable actual duty of water along these canals.

Practice of irrigation.

The practice of irrigation by flooding is rendered necessary in the districts irrigated by these canals on account of the peculiar nature of the soil.

It is usually done during the daytime, when the greatest loss by evaporation occurs, which may in a great degree account for the low duty performed by each cubic foot per second..

Irrigation in the Mussel Slough District.

Location and area of Mussel Slough District.

That portion of the Mussel Slough country which is now under cultivation by irrigation and supplied with water by the present canal system, is located almost entirely in Tulare County.

It is bounded on the north and west by Kings River, on the south by the swamp and overflowed boundary line along Tulare Lake, and on the east by Cross Creek and the San Joaquin Valley Railroad—and contains 155,000 acres, of which it is estimated that not less than 115,000 acres are altogether suited to irrigation, leaving 40,000 acres not of good irrigable quality, the principal part of which is located along Kings River below Kingston, where it is subject to overflow, and in the vicinity of the Central Pacific Railroad east of Burr's Slough, where the soil is so highly charged with alkali as to render its cultivation by irrigation unprofitable.

The sources of water supply.

Kings River is the proper source of supply for all the territory herein designated as the Mussel Slough country. The water of the Kaweah River, including that which is now claimed by the Settlers

and Lake Side Canals, should be used for irrigation on the plains in the region of the foothills, particularly to the south, and within its delta, which may be described as extending from the point where the river leaves the foothills through to Tulare Lake. The estimated capacity of the seven canals, which at present supply the Mussel Slough country, is 1,040 cubic feet per second, of which 890 cubic feet per second are supplied by Kings River, leaving 150 cubic feet per second as the amount delivered to the two canals by the Kaweah River, through Cross Creek, which could be readily supplied to them from Kings River by enlarging the headworks and channel of the People's Canal so as to enable it to carry the additional 150 cubic feet per second required by these canals.

Theoretical duty of canals in district.

Assuming that one cubic foot per second will irrigate 100 acres, the total water quantity which the canals, in their present condition, are capable of carrying would irrigate 104,000 acres, or 67 per cent. of the total number of acres in the district, or 90 per cent. of the number of acres estimated as irrigable lands.

Again, if we assume that one cubic foot per second will irrigate 150 acres, the same amount of 1,040 cubic feet per second would irrigate 156,000 acres, or 1,000 acres more than the whole number of acres in the district, or 41,000 acres more than the total amount estimated as irrigable lands.

Future duty of water.

In the future, when the whole district is settled up, and brought under cultivation by irrigation, it is probable that not more than four-fifths of the area estimated as irrigable will be under cultivation during any one season, in which case there would be but 88,000 acres for which to provide water, so that the number of acres to be irrigated by each cubic foot per second of maximum capacity of the canals canstructed would be about 85—a sufficiently low duty to ensure an abundant supply for all possible demands upon the canals for stock and domestic purposes, also. But suppose 104,000 acres should be under cultivation each year; even then the 1,040 cubic feet per second, which the present canals are capable of carrying, would be called upon to irrigate only about 100 acres per cubic foot per second—a duty which cannot be considered by any means high, when the whole district is once brought under a careful and economical system of cultivation and distribution of water.

Conclusions.

From this it is fair to conclude that, with such modifications and extensions as may be rendered necessary from time to time as the demand upon the canals increases, they can be made at small cost to serve the purpose of irrigating the entire Mussel Slough country, without diverting any more water than they now have the capacity to carry.

Crop statistics, Mussel Slough District.

During the summer of 1878, Mr. John S. Urton was employed by this department to collect statistics on the character of crops irrigated in the Mussel Slough country by each of the canals. The results of his painstaking work are shown in the following interesting table:

TABLE

Showing the number of acres and kind of crops raised by irrigation in Mussel Slough country, during the irrigation season of 1877–78.

Name of Canals.	Acres in Cultivation—and in what Cultivated.														Totals.
	Wheat	Barley	Oats	Alfalfa	Corn	Beans	Potatoes	Vegetables	Orchard	Vineyard	Forest	Broom corn	Egyptian corn		
People's Ditch	9,159	985	------	1,173	547	151½	47½	31	87	5	72	------	81	------	12,340
Mussel Slough	1,270	255	------	56	75	------	4	4	3	------	------	------	18	------	1,685
Last Chance	6,798	2,133	------	2,330	282	142½	29	40	57	34	16	13	165	------	12,040
Lower Kings River	5,063	587	------	342	15	5	------	41	15	12	------	4	------	------	6,084
Rhodes' Ditch	1,058	240	------	371	65	------	1	8	22	10	------	------	------	------	1,775
Totals	23,348	4,200	------	4,272	984	299	81	124	184	61	88	17	264	------	33,924
Settlers' Ditch	5,684	919	17	616	217	14	14	28	52	16	71	------	131	------	7,779
Lake Side	3,571	607	------	773	290	51	1	5	25	18	63	11	149	------	5,564
Totals	9,255	1,526	17	1,389	507	65	15	33	77	34	134	11	280	------	13,343
Grand totals	32,603	5,726	17	5,661	1,491	364	96	157	261	95	222	28	544	------	47,267

Remarks on the foregoing table.

It will be seen by the preceding table that the total number of acres irrigated by the five canals from Kings River (those first named in the table), was 33,924, of which there are 4,272 acres planted in alfalfa.

The total number of acres irrigated by the two canals from the Kaweah was 13,343, of which there are 1,389 acres in alfalfa, making a total of 47,267 acres cultivated by irrigation in the Mussel Slough country during 1878.

Deducting the number of acres of land now under cultivation by irrigation from the 115,000 acres which are estimated as the total area susceptible of irrigation, we have 73,000 acres yet to be provided with water and the necessary facilities for its distribution.

The present arrangement of canals, including the two from the Kaweah River, can be so modified and extended as to supply water to the whole area estimated as "irrigable lands," from Kings River.

The advisability of doing so has been referred to further on, under the head of Duplication of Canals, etc.

Area irrigated in 1879.

The following table compiled from data also furnished by Mr. Urton, shows the total area irrigated in the same district during the past year, but does not give the detail shown in the estimate of 1878. The aggregate of the two years is shown side by side. It will be seen that the canals derived from Kings River show an increase of acreage irrigated of nearly 10½ per cent. in 1879, over that of 1878. The supply from Kaweah River was unusually short, so that the two canals from that stream present a great falling off from the duty performed by them in 1878, and the total area irrigated in the district is thereby decreased. They received no water until May, and ceased flowing some time during the latter part of June.

TABLE

Showing extent of irrigated land in the Mussel Slough District—1878 *and* 1879.

Name of Canal.	Acres irrigated in 1878.	Acres irrigated in 1879.
People's	12,340	13,340
Mussel Slough	1,685	3,846
Last Chance	12,040	13,040
Lower Kings River	6,084	6,084
Rhodes' Ditch	1,775	1,600
Total	33,924	37,910
Settlers	7,779	1,750
Lake Side	5,564	1,400
Total	13,343	3,150
Grand total	47,267	41,060

To provide water for the 41,060 acres cultivated during 1879, the canals were not taxed to more than half their estimated capacity in their present condition.

Duty of water in 1879.

The highest duty of water is found in the case of the Lower Kings River Water Ditch, where one cubic foot per second of the amount applied irrigated 168 acres, while in the case of the People's Ditch, and that of the Last Chance Ditch Company, which two may be taken as the most satisfactory examples, one cubic foot per second of the amout of water applied irrigated, in the case of the first ditch, 106 acres, and in the case of the latter, 108 acres.

The lowest duty performed is in case of the Mussel Slough Ditch, where only 25 acres per cubic foot per second were irrigated.

This showing possibly is due in some degree to the want of satisfactory data regarding the probable amount applied for irrigation from this ditch.

Character of crops cultivated.

The crops cultivated by irrigation along Kings River are wheat, barley, Indian corn, Egyptian corn, broom corn, millet, and sorghum. All varieties of fruit and vegetables common to California are successfully grown. Alfalfa, which is the only grass raised by irrigation, is usually sown in February—and the first year it can be cut three times, yielding from one to one and a half tons per acre each cutting. When two or three years old it can be cut five or six times, yielding from one to two tons per acre. The rule is to cut it once in every six weeks—in cases where it is not used for stock-pasture. In the Mussel Slough country where the conditions are highly favorable for the growth of alfalfa, it is never watered more than twice a year, when it is flooded during one of the irrigations, more particularly for the purpose of destroying gophers, which usually infest the alfalfa fields.

There are some localities in which it is unnecessary to apply water for any other purpose, as the soil contains sufficient moisture, supplied by seepage during the entire year, to insure an abundant crop.

Wheat is usually watered by seepage—flooding being resorted to only in exceptional localities and cases.

Corn, and other summer crops, are irrigated by flooding, except in localities where seepage keeps the moisture near the surface.

DUTY OF WATER FROM KINGS RIVER.

There were irrigated by the Kings River Canal system, during the year ending October 31st, 1879, in the aggregate 61,210 acres, of which 21,300 are located on the north side of the river and 39,910 on the south.

The 20,690,253,000 cubic feet of water (which is equivalent to a mean discharge of 656 cubic feet per second) used for irrigation for the year ending October 31st, 1879, without allowing for loss by evaporation and other causes, if evenly distributed over the total area irrigated, would cover it with water to the depth of 7.75 feet, or 474,983 acres one foot deep, while each cubic foot per second was required to irrigate 90.4 acres, which is the mean given of all the canals.

The lowest duty performed by water per cubic foot per second was in the irrigated districts north of the river, while the highest was in those south.

Assuming that seventy-five per cent of the whole amount of water supplied by the river during the year ending October 31st, 1879, which is equivalent to 40,941,894,450 cubic feet, or a mean discharge

of 1,290 cubic feet per second, could have been diverted and used for irrigation, and allowing a duty of 50, 100, and 150 acres per cubic foot per second, it would irrigate 64,500, 129,000, and 193,000 acres respectively. Or again, if we assume that seventy-five per cent of the amount supplied by the river during the second and third irrigation periods (which extend from January 31st, to July 31st 1879, and are the seasons of greatest demand for water for irrigation), which is equivalent to 36,742,474,800 cubic feet, or a mean discharge of 2,350 cubic feet per second, could have been diverted and used for irrigation, and allowing the same duty for water as that given above, it would irrigate 117,500, 235,000, and 352,500 acres respectively.

AVERAGE COST PER ACRE OF FARMING BY IRRIGATION IN THE MUSSEL SLOUGH COUNTRY.

The cost of water to persons who purchase it from the canal owners is from $1 to $1 50 per acre for the irrigation season.

The cost of the labor of distributing water is from $0 25 to $1 per acre; the average being about $0 50 per acre.

The cost of distributing ditches is from $0 50 to $2 per acre—depending upon the size.

The cost of plowing and preparing land for sowing is from $1 25 to $1 75 per acre.

The cost of harvesting, including stacking, is from $1 50 to $2 per acre.

The yield of wheat is from twenty to forty bushels per acre.

The yield of barley is from thirty-five to fifty bushels per acre.

VALUE OF LAND IN THE MUSSEL SLOUGH COUNTRY.

Land not susceptible or adapted to cultivation by irrigation is valued at from $1 25 to $2 per acre.

Land susceptible of cultivation by irrigation, but without improvement or facilities for irrigation, is valued at from $5 to $20 per acrre.

Land now under cultivation by irrigation, with its improvements, is valued at from $20 to $50, the price varying with its proximity to the main canals or their principal branches, and depending in some degree upon its adaptation to irrigation by seepage or percolation, as well as its fertility.

The most valuable land is located around Grangeville and along the banks of Mussel Slough.

The soil is a dark sandy loam underlaid with coarse sand; in some localities the sub-soil is "hard pan."

The whole area is more or less spotted with alkali; in some limited localities the soil is so highly charged with it as to be unfit for agricultural purposes.

IRRIGATION PERIODS.

The year has been divided into what appear to be four natural irrigation periods of three months each, commencing November first and ending October thirty-first.

The first period is the one in which water is needed more for the purpose of preparing the land for seeding, while the second and third periods are those of greatest demand for water for irrigating the winter and spring crops, and the fourth period that of the summer

crops, which are usually planted the latter part of the third period, or after the grain has been harvested.

EFFECT OF IRRIGATION ON SOILS IN THE MUSSEL SLOUGH COUNTRY.

Irrigation always compacts and hardens the soil, especially when the water is applied by flooding, and sometimes to a very inconvenient degree. Of course land is softened for the moment by watering, though in drying it becomes harder than before.

It is customary in the Mussel Slough country, when water can be gotten, to irrigate the ground after taking off a summer crop, in order both to soften it for plowing for autumn sowing, and to hasten the sprouting of the winter grain sown upon it.

In localities where the soil is a light, sandy loam, and irrigation is accomplished entirely by seepage or percolation, the original characteristics and fertility of the soil seem, as far as the experience in this section goes, to remain in a great degree unchanged.

There are tracts of land, however, the subsoil of which is so thoroughly impregnated with alkali as to render the surface hopelessly barren.

In some sections, where the surface soil is practically free from alkali, but with the subsoil strongly alkaline, and where it has been under cultivation and irrigated by seepage for several years, it has become so highly charged with alkali as to be unfit for profitable cultivation by irrigation.

The alkali land is usually covered with a dense growth of alkali weeds and salt grass, which are unfit for any use to either the stock raiser or farmer.

DRAINAGE IN THE MUSSEL SLOUGH DISTRICT.

Irrigation cannot be successfully practiced without adequate drainage—which, therefore, should be provided before this method of cultivation can be brought to a high stage of development.

Effect of irrigation on climate as to temperature and health.

The general opinion entertained by the residents of the irrigated settlements along Kings River is that up to the present time no prejudicial influence upon the health of the settlers has resulted in any marked degree.

But unless proper attention be paid and the necessary steps taken at once to insure a thorough drainage of the lands under cultivation by irrigation, this region, which is now healthy, will doubtless soon lose its reputation for salubrity; indeed, the evidences of this tendency are now apparent.

The natural drainage channels of the different districts under cultivation by irrigation and supplied with water from Kings River are, in several instances, occupied by irrigation canals. This is particularly the case with the Mussel Slough and the Fresno Canal, in the vicinity of Fresno, which occupies the bed of Fanshaw Creek. This was done for the purpose, no doubt, of reducing the original cost of the works.

The bad effect of using the natural drainage channels as canals was made very apparent during the past season in the Mussel Slough country. A fortunate combination of natural conditions in the

surface and subsoils, as well as the general topographical features, rendered artificial drainage, to a great degree, unnecessary in that district until within the last year.

Natural drainage.

The general slope of the Mussel Slough country is from Kings River, in a southwesterly direction, to Tulare Lake, and all of the canals and old watercourses and sloughs follow the slope of the country, and tend towards the lake, into which they discharge their surplus waters during the irrigation seasons.

The light, sandy and friable nature of the surface-soils, together with the exceedingly porous character of the sub-soils, which permit to a remarkable degree the free passage of water, acting at the same time as a filter to retain all its silt and other fertilizing qualities, has rendered it possible, to the present time, to irrigate this entire district by what is commonly known as seepage or percolation.

As frequent or constant application of water, either by flooding or percolation, always compacts and hardens the soil, it is possible that at no very distant day the free passage of water by seepage will, to a great degree, stop, and render irrigation by flooding necessary over a large portion of the land where it is now accomplished by seepage.

Changes in drainage.

It is stated that in several localities where the most satisfactory results had been realized during the first few years of irrigation by seepage, it had failed in a great degree to become "wetted up," as it is termed, by percolation during the last season, which was, and no doubt correctly, attributed to the fact that the subsoil had become compact or filled up with silt, and therefore rendered by that means impervious to water, to such an extent at least as to prevent the moisture from coming to the surface, as was the case in the beginning.

There is no reason to believe but that soils of the same kind, acted upon in a similar manner, would be thus affected also, in which event it will become necessary to provide a complete and comprehensive system of drainage for the new order or method of irrigation that would naturally follow this change in the condition of the soil and underground drainage.

The Mussel Slough drain.

It is generally conceded by the irrigators themselves that the Mussel Slough country was more thoroughly "wetted up" during the past season than at any previous time since the introduction of water for irrigation, and remained so for a longer period, which is no doubt attributable in part to the fact that the subsoils are becoming year by year less porous, and therefore less capable of conducting off the surplus waters, and particularly to the important fact that the natural underground drainage system of a large portion of the district is destroyed in a great measure by the numerous dams in the channel of Mussel Slough, where its waters are collected and held at an elevation nearly equal to the surface of the surrounding country, so as to divert it through the distributing canals and ditches to the fields under cultivation. Mussel Slough is the most important natural drainage channel in the Mussel Slough country, and should, therefore, be kept open and used for that purpose alone.

LOSS BY EVAPORATION.

The following table has been prepared for the purpose of showing the probable loss by evaporation alone from the main channel of Kings River along its course from the foothills through to Tulare Lake—a distance of 62 miles—and is based upon the observations made by this Department in Kern County, amplified by other data, obtained in localities where the meteorological conditions are similar. A mean yearly loss of about 5.5 feet is shown, which has been apportioned between the four periods, as indicated in the table for the year ending October 31st, 1879. All that is claimed for this table is a fair approximation to the truth:

TABLE

Showing the yearly loss by evaporation from Kings River.

Number of Period.	Length of period—in days	Total evaporation for the period, in feet	Rate of evaporation in cubic feet per second per square mile	Total area of water surface, in square miles	Total rate of evaporation from the whole area of water surface, in cubic feet per second	Total number of cubic feet evaporated during the period	Remarks.
First	92	0.30	1.06	3.2	3.39	26,946,432	First Period—November, December, and January.
Second	89	0.95	3.46	3.1	10.72	82,432,512	Second Period—February, March, and April.
Third	92	2.00	7.03	4.3	30.23	240,292,224	Third Period—May, June, and July.
Fourth	92	2.25	7.90	2.2	17.38	138,150,144	Fourth Period—August, September, and October.
Totals and averages	365	5.50	4.53	3.2	15.47	487,821,412	Total for year ending October 31st, 1879.

Mussel Slough country is at present supplied with water for irrigation from Kings River direct, and from the Kaweah River, through St. Johns River and Cross Creek.

There are five canals which divert the waters of the former, and two those of the latter, in all seven, which constitute the present canal system of this district.

The aggregate length of the five canals and their main branches, which take their supply from Kings River, is 110 miles.

The aggregate length of the two canals and their main branches, which take their supply from the Kaweah River, is 55 miles.

By referring to the map showing the canal system of the Mussel Slough Country, it will be seen, at a glance, that for the first several miles along the channel of each canal no water is diverted for irrigation, owing to the fact that the beds of the canals are so far below the surface of the surrounding country as to render it impossible to raise their waters to the surface and divert them for irrigation.

Allowing, say four miles to each of the five canals, there are twenty miles of the most expensive portions of each canal, together with their headgates and dams in the river, which could have been avoided had a proper plan for irrigating this district been decided upon in the beginning, and all the interests and water rights united in building one large canal, leading out from the river at some point above the head of Cole Slough, or near the foothills.

Economical location.

Even at the present stage of development of the canal system of this district, a great saving in the future cost of maintenance and distribution of water could be made by carrying out the suggestion made, of diverting all the water claimed by the present canals through one main canal above Cole Slough, or near the foothills.

Already the manifest advantages of a consolidation of the canal and water right interests of the Mussel Slough country have become apparent to the irrigators in that locality, and a move has been made in that direction by the organization of a company to divert the whole amount of water from Kings River, claimed by the canal owners in that section, by means of a large canal to be constructed from some point on the river above Centerville, near the foothills, through which they propose to conduct the respective amounts of each of the present canals, and deliver them to the canals and ditches as now constructed in their respective localities.

Instance north of the river.

If all the water claimed and appropriated by the Kings River and Fresno Canal, the Fresno Canal, and the Centerville and Kingsburg Canal, had been diverted through one large and well constructed channel and conducted several miles out on the plains, and then divided and carried by judiciously located and properly constructed canals to the districts under cultivation, a great saving would have been effected in the original cost of diverting the water claimed by each canal from the rivers, and a corresponding reduction in the price of water to the irrigators, as well as a considerable saving in the loss of water by evaporation and percolation, now resulting from the duplication of works.

Example of excessive loss due to duplication of works.

For the purpose of showing the excess of loss by evaporation and percolation in the case of two imperfectly designed and constructed canals over that of one with a properly proportioned cross-section, carrying the same quantity of water, the Fresno and the Centerville and Kingsburg Canals have been selected as examples. From the numerous measurements and cross-sections taken for the special gaugings of these canals, I am able to give what may be considered a fair average cross-section of each for the first 10 or 15 miles of their course.

The average cross-sectional dimensions of the Fresno Canal are as follows: 35 feet wide on bottom; side slopes 2 to 1; depth of water, 2 feet; and width of water-surface on top, 43 feet. This section gives an area of 78 square feet. The mean discharge of this canal for the year ending October 31st, 1879, as shown by the tables, was 187 cubic feet per second, which to pass through the above cross-section would require a mean velocity of 2.4 cubic feet per second, which is about that observed in the special gaugings. The wet perimeter or border of this cross-section is 44 feet. The superficial area of water-surface for 10 miles of this canal is equal to 2,270,400 square feet, or .082 square miles, while that of the wet perimeter is equal to 2,323,200 feet, or .083 square miles.

The average cross-sectional dimensions of the Centreville and Kingsburg Canal are as follows: 25 feet wide on bottom; side slopes 2 to 1; depth of water, 1.5 feet; and width of water-surface on top, 31 feet. This section gives an area of 42 square feet. The mean discharge of this canal for the year ending October 31st, 1879, as shown by the tables, was 83 cubic feet per second, which to pass through the above cross-section would require a mean velocity of nearly two feet per second, which corresponds closely with that given by the special gaugings. The wet perimeter or border of this cross-section is 34 feet. The superficial area of water-surface for 10 miles of this canal is equal to 1,636,800 square feet, or .059 square miles, while that of the wet perimeter is equal to 1,795,200 square feet, or .065 square miles. The total superficial area of water-surface for 10 miles of these two canals is equal to 3,907,200 square feet, or .141 square miles, while that of the wet perimeter is 4,118,400 square feet, or .148 square miles.

Illustration.

Let us now assume, for example, that a new channel were to be made as a substitute for the two canals just mentioned, having a capacity equal to both. The cross-sectional dimensions of such a canal may be taken as follows: 23.85 feet wide on bottom—side slopes two to one—depth of water 3.5 feet, and width of water surface on top 37.85 feet. This section gives an area of 108 square feet. The mean discharge of this canal (to be equal to the sum of the other two), would be 270 cubic feet per second, requiring a mean velocity of 2.5 feet per second, or 1.7 miles per hour. The wet perimeter or border of this cross-section would be 39.6 feet, and the superficial area of water surface for 10 miles 1,998,480 square feet, or .072 square miles, while that of the wet perimeter is equal to 2,090,880 square feet, or .075 square miles, which is just about half of the total of the two existing channels in each instance.

The average annual loss by evaporation, which is now about 0.68

cubic feet per second over the first ten miles of the existing canals, would in the case of the hypothetical channel, be reduced to 0.35 cubic feet per second, on account of the decreased area of water surface, while the loss by percolation, which is far more serious, would be correspondingly reduced by reason of the decrease in area of wetted perimeter. The cost of maintenance should also be lessened in an almost equal ratio.

The special gaugings show that the loss due to percolation alone in the case of the Fresno Canal was 2.05 cubic feet per second per linear mile of canal, while that of the Centerville and Kingsburg Canal was 1.29 cubic feet per second per linear mile. The total for both canals is 3.34 cubic feet per second per linear mile.

The saving effected by conveying the amount of water estimated upon in one well constructed canal, as against the result of leading it in two channels, would be 1.7 cubic feet per second per linear mile, or about 50 cubic feet per second for the length of the Fresno Canal and its main branch—an amount equal to nearly 20 per cent. of the quantity conveyed.

PREPARATION OF THE GROUND.

In the Mussel Slough country, where irrigation is accomplished almost entirely by seepage or percolation, and where the general surface of the ground in its natural condition is more or less even, the irrigators have as a rule paid but little, if any, attention to the preparation of the land for cultivation by irrigation, although it is apparent in localities where the land is naturally even and uniform, that the whole surface becomes more evenly and uniformly wetted up, and the crops therefore are also, in a corresponding degree, found to give a more satisfactory average yield per acre.

That portion of the Mussel Slough country which has been under constant cultivation since the introduction of water into the country for irrigation, has, by the frequent plowing and harrowing necessary in the preparation of the ground for seeding and the cultivation of the crops, become, in a great degree, as smooth of surface as is probably necessary where flooding is not resorted to for the purpose of watering the crops.

In the colonies.

North of Kings River, particularly in the colonies around Fresno, where the irrigators hold small parcels of land, frequently of not over 20 or 40 acres each, and where crops are irrigated by flooding, the previous preparation of the land by leveling and building checks is found to be, in a great measure, absolutely necessary.

But even there it has not been carried out as thoroughly and completely as it should be, to insure the least waste of water, as well as its rapid and satisfactory distribution over the area to be flooded—nor has the important matter of drainage been properly incorporated with the present system of irrigation.

There is no doubt but that a great saving in the quantity of water now used to irrigate a given area of land can be made to follow a thorough and proper preparation of its surface for the reception of water.

MEASUREMENT OF WATER.

The measurement of the water supplied to the irrigators, in Tulare and Fresno Counties, is by no means uniform or accurate.

In the Mussel Slough country it is generally effected by means of a gate of given dimensions fixed at the head of the distributing ditch, which is arranged so that it may be raised to a mark designating the number of shares or parts of a share of water passing through the opening.

The exact quantity of water discharged under a given head is not ascertained by any arbitrary rule, but is estimated and agreed upon by irrigators, as a matter of custom and convenience among themselves.

The actual quantity of water which may flow through these openings depends upon many varying circumstances and conditions, such as the size of the main canal, its position with regard to the course of the main current, with other modifying influences, all of which may cause differences in the quantities discharged through openings of the same size.

The coöperative plan.

In all cases where the irrigators own the canals themselves, the entire quantity of water in each canal available for irrigation is divided into as many parts as there are shares of stock in the company.

For instance, a canal in which there are, say, 100 shares, each share represents $\frac{1}{100}$ part of the water in the canal. The headgates, through which the water is diverted for irrigation from the main canal, are so constructed and arranged as to allow the pro rata of each share owner to pass from the canal into the small distributing ditches. By this simple arrangement each irrigator receives his portion of the water actually available for irrigation during the different stages of water in the canal.

In case of sale or rent of water, the same system or mode of measurement is used, as the water is sold or rented for the year or season by the share or fractional part of a share.

Sale of water privileges.

The Fresno Canal and Irrigation Company sell water rights extending over a period of 50 years, each right being supposed to represent one cubic foot per second, and to be applied to 160 acres of land, the description of which is given in the deed, the right applying to no other tract than the one described. The water and the land are thus definitely united in the proportion of one cubic foot per second to each 160 acres. The supply is at all times distributed from the canal to the lands of the owners of water rights or privileges, under the direction of the superintendent of the canal works, and apportioned according to his judgment.

CHAPTER III.

WATER CLAIMS AND RECORDS THEREOF.

The words of the statute relating to the location and appropriation of water in the State, which are intended to define, or rather determine, the manner of measuring the amount of water claimed in each instance, are: "inches, measured under a four-inch pressure."

Taking the amount of water discharged through an inch-square opening, under a four-inch pressure, at .02 cubic feet per second (which is about the mean given by several different authorities), we

have fifty square inches under four-inch pressure, equal to one cubic foot per second, which has been used as the multiplier in every case where it could be applied in estimating the equivalent in cubic feet per second of the amount of water claimed by the different canal companies or persons mentioned in the abstract of filings in this office. The language of the filings in many cases is so indefinite and incomplete, in reference to the amount of water claimed, that it is difficult to interpret it with any degree of certainty. In most cases where the language of the filing is different from that which the law requires the applicant or appropriator to use in stating the amount of water claimed, the filings are themselves so defective, for the want of complete data for estimating the exact quantity, that they have to be omitted altogether in the following tables, and referred to in a separate statement showing the probable amount claimed in the aggregate, by all the filings which are indefinite regarding this particular point.

Supplementary and additional claims.

In the case of several canals referred to in the following pages, there are two or more claims on record made at different times, and in some instances by different persons in the name of the same company.

As it is not stated in the abstracts of filings whether later claims are to be considered as additions to those previously made, or that the difference, in cases where the last filings call for a greater amount than the first, is to be taken as an additional quantity, or that the whole amount called for is to be considered as the amount of the claim made by the last filing, or whether the sum of all the filings is to be taken as the total amount claimed, it has been thought advisable to consider the amount of each claim as an addition to those previously filed.

It is not probable that the company or persons would abandon the first claim, by which priority to the use and appropriation of water was established, for the purpose of increasing the amount by a subsequent filing, which would in any way invalidate their claim made in the first instance.

For the purposes of this report the aggregate of the amounts called for, in all cases where there are more than one filing, is taken as the total claimed by the company.

Water claims on Kings River.

The abstracts of filings of "water rights and claims" up to December, 1879, as shown by the records of the Recorder's office in Fresno and Tulare Counties, copies of which have been furnished this department by Dixon and Faymonville for the former, and D. K. Zumwalt for the latter, show that there are in Fresno sixty, and in Tulare County twenty-three claims on file for water from Kings River, making a total of eighty-three in the two counties.

Of the sixty filings on record in Fresno County, and the twenty-three in Tulare County, there are twenty-eight in the former and fourteen in the latter in which the amount of water claimed is clearly stated in the language of the law relating to the appropriation and use of water, which in the first case amounts in the aggregate to 708,796 inches of water under a four-inch pressure, or its equivalent of 14,176 cubic feet per second, and in the second case to 486,148

inches of water under a four-inch pressure, or its equivalent of 9,723 cubic feet per second, making a total amount of water claimed from King's River, by the filings, which conform to the law in both counties, 23,899 cubic feet per second. Many of these may be the same claim filed in both counties. Some undoubtedly are, for it is known that this is the case in several instances; but in the absence of satisfactory information regarding this particular point, it is thought best for the purposes of this report to mention the total amount of all the claims.

There are among the filings in Fresno and Tulare Counties, which claim the water from Kings River, several which do not state the amount of their claims, and others in which the data, referring to the quantity of water claimed, is not sufficiently complete to estimate or even approximate the quantity called for.

Several of the filings in Fresno County call for, in each case, all the water that Kings River can supply.

The abstracts of filings show that there are 114 claims on record for water from the different rivers and streams in Fresno County, and 199 from those in Tulare County, making a total of 313 in the two counties.

Extent of claims and water supply.

It may be well to state in this connection that the maximum discharge of Kings River for the past year, as shown by the observations and measurements of this Department, was only 9,030 cubic feet per second, while the minimum discharge was as low as 210, and the mean for the year ending October 31st, 1879, was 1,719 cubic feet per second; from which it will be seen that the amount claimed by those filings alone, which are mentioned in the preceding pages, is about two and a half times greater than the maximum discharge of the river and about fourteen times greater than the mean discharge.

There are at present about 14 canals and ditches actually constructed and in use, which divert their water supply from the river, through separate headgates at various points along its channels, from the foothills to Tulare Lake.

The extent of the claim to water for each of these works is now presented, as made up from the filings. There is of course considerable latitude possible in some instances, but in the absence of sworn evidence the results are probably as near correct as can be obtained, with the notable allowance, before mentioned, to be made for duplication of filings in the two counties.

The following table was prepared for the purpose of showing the relation between the amounts claimed, the estimated maximum capacity, the mean discharge from January 31st to July 31st, 1879, a period of six months; and the greatest discharge at any time during the year ending October 31st, 1879, together with the month in which it occurred, for each of the canals named therein.

The figures in the second column are taken from the preceding pages, where the data regarding each canal is given in full, while those for the third column are based upon the observations and measurements made by the Department during the past year, and those in the fourth column are the mean given for the period mentioned therein by the tables containing the results obtained from actual gaugings, as are those also in the fifth and last column:

Name of Canal.	Estimated equivalent in cubic feet per second of the amount of water claimed	Estimated maximum capacity, cubic feet per second	Mean discharge Jan. 31st to July 31st inclusive, 1879—cubic feet per second	Greatest discharge at any time during season	Date of greatest discharge. 1879.
Kings River and Fresno	852	200	66.4	157	January.
Fresno	2,700	500	261.4	330	May and June.
Centerville and Kingsburg	300	200	116.7	170	May.
Emigrants'	80	80	42.5	73	May.
Total	3,932	980	487.0		
People's	1,152	280	140.8	279	May.
Mussel Slough	864	350	112.7	600	May.
Last Chance	288	185	132.1	175	May.
Lower Kings River Water Ditch	315	50	42.5	45	May.
Rhodes'	44	25	15.6	24	May.
Total	2,663	890	443.7		
Settlers'	432	75			May.
Lake Side	660	75			May.
Total	1,090	150			
Nine Canals from Kings River	6,595	1,870	930.7		

CHAPTER IV.

HYDROLOGICAL DATA.

Water diverted for irrigation.

The following tables show the amount supplied by Kings River, and the amount diverted during each of the four periods, and for the whole of the year ending October 31st, 1879.

First Period—November, December, and January, 1878-9.

Second Period—February, March, and April, 1879.

Third Period—May, June, and July, 1879.

Fourth Period—August, September, and October, 1879.

This group of tables is designed to indicate the water quantity diverted from Kings River by each of the principal canals during the four irrigation periods into which the year, beginning November 1st, 1878, and ending October 31st, 1879, has been divided. The figures in the final column show the areas that might have been irrigated to a depth of one foot, if that quantity only had sufficed, and when compared with the column showing the actual area irrigated during the year, give a better idea of the duty accomplished with the water than any other.

Table No. 5 gives a summary of the entire diversion of water for the year, from which it is seen that a sufficient amount was taken out to have covered the lands irrigated to an average depth of 10.93 feet, while the average discharge of all the canals through the year performed a duty of but 48.8 acres per cubic foot per second thus diverted.

TABLE NO. 1,

Showing the amount of water supplied by Kings River, and the amount diverted during the first period of the year ending October 31st, 1879.

NOVEMBER, DECEMBER, AND JANUARY.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigtaed in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic feet per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	77	1	157	3	3	42.	279,417,600	1,500	4.27	35.76	6,414.5
Fresno	92	1	212	84	113	106.	842,572,800	8,500	4.27	80.18	19,342.8
Centerville and Kingsburg	92	1	123	5	14	45.	357,696,000	3,000	2.73	66.66	8,211.5
Total and averages							1,479,686,400	13,000			33,968.8
Emigrant	8	1	37	1	3	20.	13,824,000	5,800	.05	290.00	317.3
Grant	7					20.	12,096,000	1,000	.27	50.	277.7
Murphy's Slough	7					40.	24,192,000	1,500	.37	37.50	555.5
Total and averages							50,112,000	8,300			1,150.5
Kincaid	92	2	19	87	9	9.48	75,340,800	1,000	1.72	105.48	1,729.6
People's	7	1	87	1	7	43.38	26,438,400	13,340	.04	306.84	606.9
Mussel Slough	No water.							3,846			
Last Chance	7	1	100	1	36	71.57	43,286,400	13,040	.07	182.19	993.7
Sutherland Slough	No water.							1,000			
Lower Kings River	92					50.	397,500,000	6,084	1.50	121.68	9,125.5
Rhodes'	No water.							1,600			
Total and averages							542,565,600				12,455.7
Grand total and averages							2,072,364,000	61.210	0.77		47,574.9
Kings River	92	1	3,425	23	210	320.	2,549,307,200				58,524.

TABLE NO. 2,

Showing the amount of water supplied by Kings River, and the amount diverted during the second period of the year ending October 31st, 1879.

FEBRUARY, MARCH, AND APRIL.

NAME OF CANALS.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	12	2	107	2	71	103.42	107,222,400	1,500	1.63	14.50	2,461.2
Fresno	89	9	302	12	136	214.69	1,650,931,200	8,500	4.45	39.59	37,900.2
Centerville and Kingsburg	89	5	133	1	14	103.50	795,916,800	3,000	6.07	28.02	18,271.7
Total and averages						421.61	2,554,070,400	13,000		30.83	58,633.1
Emigrant	89					34.99	269,136,000	5,800	1.08	165.76	6,178.5
Grant	89					17.19	132,244,700	1,000	3.03	58.17	3,035.9
Murphy's Slough	89					67.94	522,463,800	1,500	8.00	22.05	11,994.1
Total and averages						120.03	923,844,500	8,300		69.15	21,208.5
Kincaid	89	30	35	10	9	23.99	184,464,000	1,000	3.98	41.68	4,234.7
People's	89	3	279	4	17	136.85	1,052,352,000	13,340	1.80	97.47	24,158.7
Mussel Slough	41	1	521			127.49	451,612,800	3,846	2.09	30.16	10,367.6
Last Chance	89	9	133	4	36	94.18	726,192,000	13,040	1.28	138.50	16,671.1
Sutherland Slough	89					31.48	242,064,000	1,000	5.55	31.76	5,557.0
Lower Kings River	89					45.00	3,460,320,000	6,084	13.06	13.52	79,438.0
Rhodes'	61	30	24			19.96	105,235,200	1,600	1.51	80.16	2,415.8
Total and averages						478.95	6,222,240,000	39,910		83.33	142,842.9
Grand total and averages							9,700,154,900	61,210	3.68	59.98	22,268.5
Kings River	89	1	8,400	1	295	2650.00	20,714,832,000				47,554.6

TABLE NO. 3,

Showing the amount of water supplied by Kings River, and the amount diverted during the third period of the year ending October 31st, 1879.

MAY, JUNE, AND JULY.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic feet per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	92	59	133	13	83	117.16	931,328,000	1,500	14.08	12.05	21,380.3
Fresno	92	61	330	13	212	308.17	2,449,612,800	8,500	6.61	27.57	56,235.4
Centerville and Kingsburg	92	1	170	1	29	129.93	1,032,825,600	3,000	7.90	20.57	23,708.1
Total and averages						555.26	4,413,766,400	13,000		23.39	101,323.5
Emigrant	92	14	73	5	25	50.00	397,440,000	5,800	1.57	116.00	9,123.9
Grant	92					29.55	234,921,600	1,000	5.39	33.84	5,393.0
Murphy's Slough	92					130.00	1,033,344,000	1,500	15.78	11.54	23,724.6
Total and averages						209.55	1,665,705,600	8,300		39.61	38,241.5
Kincaid	92	22	35	17	14	26.96	214,358,400	1,000	4.92	37.10	4.920.9
Peoples	92	7	279	16	77	144.81	1,151,107,200	13,340	1.97	92.12	26,425.8
Mussel Slough	92	2	601	1	2	165.00	1,311,542,000	3,846	8.19	23.31	30,108.8
Last Chance	92	22	175	32	166	169.98	1,351,160,000	13,040	2.20	76.85	31,018.3
Sutherland Slough	92					56.73	450,720,000	1,000	10.34	17.62	10,347.1
Lower Kings River	92					550.	4,371,840,000	6,084	15.81	11.06	100,363.6
Rhodes	92	31	30	31	6	17.62	139,970,400	1,600	2.01	90.81	3,213.2
Total and averages						1131.10	8,990,698,000	39,910		35.28	206,397.7
Grand total and averages						1896.91	15,070,170,000	61,210	5.69	32.22	345,963.
Kings River	92	1	9,030	1	635	3523.00	28,275,134,400				64,910.7

TABLE NO. 4,

Showing the amount of water supplied by Kings River, and the amount diverted during the fourth *period of the year ending October* 31*st*, 1879.

AUGUST, SEPTEMBER, AND OCTOBER.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	92					60.02	477,128,000	1,500	7.30	24.99	10,953.3
Fresno	92					120.05	954,256,000	8,500	.28	69.19	21,906.7
Centerville and Kingsburg	92					50.	397,440,000	3,000	3.04	60.00	9,123.9
Total and averages						230.07	1,828,824,000	13,000			41,983.9
Emigrant	No water.							5,800			
Grant	No water.							1,000			
Murphy's Slough	No water.							1,500			
Total and averages								8,300			
Kincaid	92					15.	119,232,000	1,000	2.74	66.66	2,737.2
People's	18	9	36	8	7	8.24	12,832,000	13,340	0.02	1,618.80	294.5
Mussel Slough	No water.							3,846			
Last Chance	19	1	54	3	9	27.94	45,878,400	13,040	0.09	466.72	1,053.2
Sutherland Slough	No water.							1,000			
Lower Kings River	92					35.	278,208,000	6,084	1.05	173.80	6,386.8
Rhodes'	No water.							1,600			
Total and averages						86.18	456,150,400				10,471.7
Grand total and averages						287.58	2,284,974,400	61,210	0.89	212.84	52,455.6
Kings River	92	31	560	31	240	383.	3,049,920,000				7,001.7

TABLE NO. 5,

Showing the total amount of water supplied by Kings River, and the total amount diverted during the year ending October 31st, 1879.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	273	1	157	3	3	76.06	1,795,096,000	1,500	27.47	19.71	41,209.7
Fresno	365	61	330	84	113	187.00	5,897,372,800	8,500	15.93	45.45	135,387.3
Centerville and Kingsburg	365	1	170	6	14	81.80	2,583,878,400	3,000	19.77	36.11	59,317.7
Total and averages						344.86	10,276,347,200	13,000	18.15	37.70	235,914.7
Emigrant	189	14	73	5	25	41.66	680,400,000	5,800	2.69	139.18	15,619.8
Grant	188					23.34	379,262,300	1,000	8.70	42.85	8,706.6
Murphy's Slough	188					97.27	1,579,999,800	1,500	24.18	15.41	36,271.7
Total and averages						162.27	2,639,662,100	8,300	7.33	51.15	60,598.1
Kincaid	355	52	35	97	9	18.82	593,395,200	1,000	13.85	53.20	13,622.4
People's	206	10	279	8	7	126.00	2,242,729,600	13,340	3.86	105.87	51,485.8
Mussel Slough	133	2	601			153.43	1,763,154,800	3,846	10.52	25.06	40,476.5
Last Chance	207	22	175	3	9	121.13	2,166,516,800	13,040	3.81	107.65	49,736.3
Sutherland Slough	181					44.30	692,754,000	1,000	15.83	22.55	15,904.1
Lower Kings River	365	31	50	28	26	269.78	8,507,868,000	6,084	32.10	22.55	195,313.7
Rhodes'	153	30	24	31	6	18.54	245,205,600	1,600	3.52	86.50	5,629.1
Total and averages						747.00	16,211,624,000	39,910	16.76	53.43	372,167.9
Grand total and averages						1254.13	29,127,633,300	61,210	10.93	48.80	668,678.4
Kings River	365	2	9,030	23	210	1719.00	54,589,193,600				1,253,195.

Water applied in irrigation.

The following tables show the *amount of water supplied* by Kings River, and the *amount applied* for irrigation during each of the four periods, and for the whole of the year ending October 31st, 1879:

First Period—November, December, and January, 1878–9.
Second Period—February, March, and April, 1879.
Third Period—May, June, and July, 1879.
Fourth Period—August, September, and October, 1879.

This estimate of the water-quantity applied was obtained from special gaugings in the canals at points just above where they were tapped for irrigation. Below these points the canals and their branches suffered considerable loss from percolation and evaporation, aside from the waste at their termini. A determination of this loss involved a more elaborate set of experiments and observations than it was practicable for this Department to attempt.

The difference in amounts between this group of tables and those just preceding indicate the loss in the canals from their heads to the first lands irrigated on their course.

An inspection of this group shows that the greatest amount of water applied in the entire year was in the third period—May, June, and July—when the average quantity used was 1,290.45 cubic feet per second, while in the preceding quarter the average was 818.51 cubic feet per second. In these two seasons we may reasonably assume that all the land was irrigated, so that the figures in the column next to the last, in tables seven and eight, give a very good idea of the duty performed by the water used. In the other periods water was used to much less extent than in the second and third. It is not fair, therefore, to take the whole irrigated acreage of the year in estimating the duty of water for these periods, although, having no account of the actual area wetted in those months, the column of water duty has been filled out on that basis, and is, therefore, misguiding without this explanation.

Table number ten contains a summary of water-quantity applied during the whole irrigating season of 1878–79, from which it will be seen that an average depth of 7.76 feet of water was applied to the 61,210 acres irrigated; that the average amount used during the year was 656.08 cubic feet per second, and that each cubic foot per second performed an average duty of 93.3 acres. If two feet in depth had sufficed, the water used might have irrigated 237,490 acres instead of 61,210 acres, the amount actually watered. At the same time, Kings River supplied enough water to have covered 626,600 acres to a depth of two feet.

TABLE NO. 6,

Showing the amount of water supplied by Kings River, and the amount applied for irrigation during the first period of the year ending October 31st, 1879.

NOVEMBER, DECEMBER, AND JANUARY.

Name of Canal.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	77	1	157	3	3	42.	279,417,600	1,500	4.27	35.76	6,414.5
Fresno	92	1	212	84	113	106.	842,572,800	8,500	2.27	80.18	19,342.8
Centerville and Kingsburg	92	1	123	5	14	45.	357,696,000	3,000	2.73	66.66	8,211.5
Total and averages						193.	1,479,686,400	13,000			33,968.8
Emigrant	8	1	37	1	3	20.	13,824,000	5,800	.05	290.00	317.3
Grant	7					20.	12,096,000	1,000	.27	50.00	277.7
Murphy's Slough	7					20.	12,096,000	1,500	.18	75.00	277.7
Total and averages						60.	38,016,000	8,300			872.7
Kincaid	92	2	19	87	9	9.48	75,340,800	1,000	1.72	105.48	1,729.6
People's	7	1	87	1	7	43.38	26,438,400	13,340	.04	306.84	606.9
Mussel Slough	No water.							3,846			
Last Chance	7	1	100	1	36	71.57	43,286,400	13,040	.07	182.19	993.7
Sutherland Slough	No water.							1,000			
Lower Kings River	92					25.	198,720,000	6,084	0.74	243.36	4,561.9
Rhodes'	No water.							1,600			
Total and averages						149.43	343,785,600	39,910			7,892.1
Grand total and averages						234.44	1,861,488,000	61,210	0.69	261.58	42,733.9
Kings River	92	1	3,425	23	210	320.	2,549,307,200				58,524.

TABLE NO. 7,

Showing the amount of water supplied by Kings River, and the amount applied for irrigation during the second period of the year ending October 31st, 1879.

FEBRUARY, MARCH, AND APRIL.

NAME OF CANALS.	Period of flow, in days	MAXIMUM RATE OF DISCHARGE.		MINIMUM RATE OF DISCHARGE.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	12	2	107	2	71	103.42	107,222,400	1,500	1.63	14.50	2,461.2
Fresno	89	9	302	12	136	214.69	1,650,931,200	8,500	4.45	39.59	37,900.2
Centerville and Kingsburg	89	5	133	1	14	103.50	795,916,800	3,000	6.07	28.02	18,271.7
Total and averages						421.61	2,554,070,400	13,000	4.51	30.83	58,633.1
Emigrant	89					34.99	269,136,000	5,800	1.08	165.76	6,178.5
Grant	89					17.19	132,244,700	1,000	3.03	58.17	3,035.9
Murphy's Slough	89					35.00	261,231,900	1,500	3.99	42.85	5,997.0
Total and averages						87.18	662,612,600	8,300	1.83	95.20	15,211.4
Kincaid	89	30	35	10	9	23.99	184,464,000	1,000	2.98	41.68	4,234.7
People's	89	3	279	4	17	136.85	1,052,352,000	13,340	1.80	97.47	24,158.7
Mussel Slough	41	1	521			127.49	451,612,800	3,846	2.09	30.16	11,367.6
Last Chance	89	9	133	4	36	94.18	726,192,000	13,040	1.28	138.50	16,671.1
Sutherland Slough	89					31.48	242,064,000	1,000	5.55	31.76	5,557.0
Lower Kings River	89	30	45	28	26	40.00	307,584,000	6,084	1.16	154.10	7,061.1
Rhodes'	61	30	24			19.96	105,235,200	1,600	1.51	80.16	2,415.8
Total and averages						473.95	3,069,504,000	39,910	1.77	84.27	71,466.0
Grand total and averages						818.51	6,286,187,000	61,210	2.35	74.82	144,310.9
Kings River	89	1	8,400	1	295	2650.00	20,714,832,000				47,554.6

TABLE NO. 8.

Showing the amount of water supplied by Kings River, and the amount applied for irrigation during the third *period of the year ending October* 31*st*, 1879.

MAY, JUNE, AND JULY.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	92	59	133	13	83	117.16	931,328,000	1,500	14.08	12.80	21,380.3
Fresno	92	61	330	13	212	308.17	2,449,612,800	8,500	6.61	27.57	56,235.4
Centerville and Kingsburg	92	1	170	1	29	129.93	1,032,825,600	3,000	7.90	23.08	23,708.1
Total and averages						545.26	4,413,766,400	13,000	7.93	23.84	101,323.8
Emigrant	92	14	73	5	25	50.00	397,440,000	5,800	1.57	116.00	9,123.9
Grant	92					29.55	234,921,600	1,000	5.39	33.84	5,393.0
Murphy's Slough	92					29.55	234,921,600	1,500	3.59	50.76	5,393.0
Total and averages						109.10	867,283,200	8,300	2.39	76.07	19,909.9
Kincaid	92	22	35	17	14	26.96	214,358,400	1,000	4.92	37.09	4,920.9
People's	92	7	279	16	77	144.81	1,151,107,200	13,340	1.97	92.12	26,425.8
Mussel Slough	92	2	601	1	2	165.00	1,311,542,000	3,846	8.19	23.31	30,108.8
Last Chance	92	22	175	32	166	169.98	1,351,160,000	13,040	2.20	77.12	31,018.3
Sutherland Slough	92					56.73	450,720,000	1,000	10.34	17.62	10,347.1
Lower Kings River	92	31	50	31	34	45	357,696,000	6,084	1.35	135.20	8,211.5
Rhodes'	92	31	30	31	6	17.62	139,970,400	1,600	2.01	90.80	3,213.2
Total and averages						626.10	4,976,554,000	39,910	2.86	63.74	114,245.6
Grand total and averages						1,290.45	10,257,603,600	61,210	3.84	47.43	235,482.2
Kings River	92	1	9,030	1	635	3,523.	28,275,134,400				649,107.

TABLE NO. 9,

Showing the amount of water supplied by Kings River, and the amount applied for irrigation during the fourth *period of the year ending October 31st*, 1879.

AUGUST, SEPTEMBER, AND OCTOBER.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge.		Minimum Rate of Discharge.		Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
		Time, in days	Amount, in cubic feet, per second	Time, in days	Amount, in cubic feet, per second						
Kings River and Fresno	92					60.02	477,128,000	1,500	7.30	24.99	10,953.3
Fresno	92					120.05	954,256,000	8,500	.28	69.19	21,906.7
Centerville and Kingsburg	92					50.00	397,440,000	3,000	3.04	60.00	9,123.9
Total and averages						230.07	1,828,824,000	13,000			41,983.9
Emigrant	No water.							5,800			
Grant	No water.							1,000			
Murphy's Slough	No water.							1,500			
Total and averages								8,300			
Kincaid	92					15.	119,232,000	1,000	2.74	66.66	2,737.2
People's	18	9	36	8	7	8.24	12,832,000	13,340	0.02	1,618.8	294.5
Mussel Slough	No water.							3,846			
Last Chance	19	1	54	3	9	27.94	45,878,400	13,040	0.09	466.72	1,053.2
Sutherland Slough	No water.							1,000			
Lower Kings River	92					35.	278,208,000	6,084	1.49	173.83	6,386.7
Rhodes'	No water.							1,600			
Total and averages						86.18	456,150,400	39,910			10,471.6
Grand total and averages						287.46	2,284,974,400	61,210	0.85	212.94	52,455.8
Kings River	92	31	560	31	240	383.	3,049,920,000				70,017.

TABLE NO. 10,

Showing the amount of water supplied by Kings River, and the amount applied for irrigation during the year ending October 31st, 1879.

Name of Canals.	Period of flow, in days	Maximum Rate of Discharge. Time, in days	Maximum Rate of Discharge. Amount, in cubic feet, per second	Minimum Rate of Discharge. Time, in days	Minimum Rate of Discharge. Amount, in cubic feet, per second	Mean discharge, in cubic feet, per second	Total amount of discharge, in cubic feet	Number of acres irrigated in 1879	Average depth of water over land irrigated	Average number of acres irrigated per cubic foot per second	Area of an equivalent, one foot deep—acres
Kings River and Fresno	273	1	157	3	3	76.06	1,795,096,000	1,500	27.47	19.71	41,209.7
Fresno	365	61	330	84	113	187.00	5,897,372,800	8,500	15.93	45.45	135,387.3
Centerville and Kingsburg	365	1	170	6	14	81.80	2,583,878,400	3,000	19.77	36.61	59,317.7
Total and averages	365					325.86	10,276,347,200	13,000	18.15	39.89	236,914.7
Emigrant	189	14	73	5	25	41.66	680,400,000	5,800	2.69	139.18	15,619.8
Grant	188					23.34	379,262,300	1,000	8.70	42.85	8,706.6
Murphy's Slough	188					31.30	508,249,500	1,500	1.37	48.25	11,667.8
Total and averages						49.71	1,567,911,800	8,300	4.34	166.77	35,994.2
Kincaid	365	52	35	97	9	18.82	593,395,200	1,000	13.85	53.20	13,622.4
People's	206	10	279	8	7	126.00	2,242,729,600	13,340	3.86	105.87	51,485.8
Mussel Slough	133	2	601			153.43	1,763,154,800	3,846	10.52	25.06	40,476.5
Last Chance	207	22	175	3	9	121.13	2,166,516,800	13,040	3.81	107.65	49,736.3
Sutherland Slongh	181					44.30	692,784,000	1,000	15.83	22.55	15,904.1
Lower Kings River	365	31	50	28	26	36.25	1,142,208,000	6,048	4.31	167.83	26,221.5
Rhodes'	153	30	24	31	6	18.54	245,205,600	1,600	3.52	86.50	5,629.1
Total and averages						280.50	8,845,994,000	39,910	5.09	142.28	203,075.7
Grand total and averages						656.08	20,690,253,000	61,210	7.76	93.30	474,982.8
Kings River	365	2	9,030	23	210	1,719	54,589,193,600				1,253,195.

NOTE.—No allowance has been made for loss by evaporation and percolation.

[APPENDIX D.]

REPORT ON WORKS AND PRACTICE OF IRRIGATION.

San Joaquin and Kings River Canal, and Chowchilla Canal.

JAMES D. SCHUYLER, ASSISTANT ENGINEER.

OFFICE STATE ENGINEER,
SACRAMENTO, Cal., December 20th, 1879.

Wm. Ham. Hall, State Engineer:

Sir—In the early part of August last I was detailed under your instructions to make an examination of the irrigation canals which derive their supply from the San Joaquin River below the upper railroad bridge. The information gleaned on this examination will form the subject of the following report.

Arranging my subjects in the order of their natural importance I will first describe that which fell under my notice on the San Joaquin and Kings River Canal.

The San Joaquin and Kings River Canal.

This canal, which takes its water through the left bank of the San Joaquin River at the junction of that stream with Fresno Slough (the overflow outlet of Tulare Lake), and passes through the Westside valley for a distance of 67 miles, is too well known, in California at least, to require more than a general account of its history. It was the first canal for irrigation of any considerable magnitude, constructed in California, in which capital was engaged as a speculative investment, and its example has proved far from encouraging to other ventures of that character, as the revenues derived have never yielded an adequate return for its enormous cost. It was constructed a distance of 38½ miles in 1871, and extended to its present terminus in 1877–78. The older section of the canal was originally made with a bottom width of 28 feet, a depth of four feet, with side slopes of one on two. In 1873, the side slopes having been considered too steep for the nature of the soil, the canal was reconstructed, deepened throughout to five and one-half feet, and given slopes sufficient for a surface width of 68 feet. The grade of the canal is one foot per mile. In building the extension from Los Baños to Orestimba Creek, 28½ miles, this grade was decreased to six inches per mile, and the bed of the canal was raised one foot higher than that of the older channel. With the experience acquired, it has been a matter of regret with the Canal Company that

the first section of the canal was not given a lighter grade, enabling it to be placed nearer the foothills and bringing under its command a larger area of excellent arable land, now above its reach. The velocity of the current is too great for the safety of the banks, and might have been much reduced without danger of troublesome deposits of silt, of which the river ordinarily carries but little.

Canal headworks.

The headworks of the canal consist of a regulating bridge, with 40 feet clear width of opening, a dam or sluiceway 55 feet in width, between the head of the canal and an island in the river, and a brush dam about 350 feet in length, connecting the island with the east or right bank of the river. The regulating bridge is a substantial structure founded on piles driven 30 to 40 feet into the quicksand bed. The sluiceway on the west side of the island is arranged to permit the passage of steamers and barges, during the season when the river is navigable, the vessels being drawn up the steep incline of its apron by means of the capstan. In low water, when the supply is insufficient to fill the canal by the ordinary flow of the current, gates in the sluiceway are raised, increasing the elevation of the water surface several feet. These gates, which are hinged at the bottom to the floor of the sluice, lie flat upon the floor during high water, and when raised are held in position by a hook and rod on the up-stream side. The whole arrangement is known as a "Falling dam," and was modeled after the Indian system for similar structures.

Maintenance of works.

The maintenance of the headworks has been difficult and costly. The brush dam has been especially troublesome, requiring constant repair and renovation as it rots and settles. The location of the headworks abreast of a sandy island, is subject to criticism and serious objection. The ends of a dam are the most difficult points to protect, if the banks be of alluvial soil, and in this case there are four of these weak spots to be watched and protected, instead of two had the dam been located in a clear reach of river.

Cost of works.

The total cost of the canal, including repairs, alterations, and improvements, is given as $1,300,000, of which $150,000 was expended in constructing the extension from Los Baños Creek to its terminus.

Distributing ditches.

The distributing system consists of the following primary ditches:

From the 10th to the 21st mile, 13 ditches, averaging about two miles in length, 12 feet wide on bottom, and two feet deep, supplying the Dos Palos Ranch.

From the 21st to the 39th mile (Los Baños Creek), 18 ditches, one-half mile to five miles long, eight to fifteen feet on bottom, supplying the Canal Farm and the Badger Flat settlement.

From the 39th to the 47th mile (San Luis Creek), four ditches, one to two miles long, eight to ten feet wide.

From 47th to 54th mile (Las Garzas Creek), four ditches, each one mile long.

From 54th to 60th mile, 10 ditches, one to four miles long, 10 to 12 feet wide.

From 60th to 67th mile (terminus at Orestimba Creek), eight ditches, from one to three miles long.

Total, 57 ditches, having an aggregate length of 110 to 120 miles. The system is being rapidly extended, as new land is brought under cultivation.

In addition to these ditches, which have been constructed by the individual land owners, the Canal Company have constructed a "loop" canal, seven miles long, parallel to the main canal and opening into it at each end, to facilitate the distribution of water to the Dos Palos Ranch. This auxiliary is 20 feet wide on the bottom, three feet deep, with side slopes of one on three. Its office is to permit water to be raised to the surface and diverted into the lateral ditches of the Dos Palos Ranch, without interfering with the flow, slope, and normal velocity of water in the main canal.

Structures.

At intervals of three to five miles on the canal are placed regulating gates, or "stop-gates," as they are locally termed, to check the flow of water when desired, and raise its elevation, in order to discharge freely through the outlet-gates into the lateral distributing ditches. On the first 39 miles there are six of these structures, of which five are combined with drawbridges, to permit the passage of canal boats, and two are connected with waste sluices. On the canal extension there are eleven stop-gates, of which eight are combined with wagon road bridges. The latter were not made in the form of drawbridges, the necessity for that class of structures having ceased with the final abandonment of navigation upon the canal. Irrigation and navigation were found to be wholly incompatible, without a system of locks to avoid the annoyance to the irrigators of opening the stop-gates for the passage of the canal boats, and the waste of water and time incident thereto. The new and simpler form of stop-gate and bridge costs but $1,000 each, while the old form of drawbridge costs from $3,000 to $5,000 each.

Aside from these combined stop-gates and bridges, there are twelve plain wagon bridges on the canal.

The old form of outlet gates to the distributing ditches consisted of a massive structure, provided with a heavy gate of four-inch planks, raised with a screw, the floor being placed exactly flush with the bottom of the canal, and the water flowing under the gate with pressure of several feet. They cost $500 each. The later structures cost but $200 each, and are of a simpler pattern. They are usually made six feet wide, in two bays, and the floor is placed about two feet below the level of the bed of the canal, to better protect the wings and lower sheet piling from the erosive back-lash of the escaping water. Loose planks, three feet long, replace the ponderous gates of the old structures, and the water enters the lateral ditch in an overfall, the quantity admitted being controlled by taking out or putting in the boards as may be required.

Present condition of the canal.

The character of the soil for the first thirty miles of the canal is an alkaline adobe, absorbing little water, but crumbling when dry and subject to constant erosion at the water's surface. Numerous expedients have been adopted to attempt to check this erosion and maintain

the banks at their normal slope. Willows have been planted along the margin, the banks have been lined with brush in the worst places, and the slopes have been sodded with salt grass, a plant which usually thrives on that kind of soil. The latter has proven most efficacious where it was induced to grow, but is expensive. Erosion is most disastrous on the convex side of the curves in the canal, showing that the wash is more due to the sharpness of the curves and the velocity of the current than to the effect of the winds which blow almost incessantly in that portion of the valley the greater part of the year, and to which the erosion was considered attributable. The plan now adopted in maintaining the canal is to add material on the *outside* of the banks where they are weakened by erosion, allowing the soil to assume whatever slope it may naturally take under the action of water, and presuming that erosion will ultimately cease when this slope is finally acquired, which is thought to be about six horizontal to one vertical. Six canal guards or section men are stationed at intervals of about 10 miles, whose duties are to watch the banks over certain sections, and to maintain them in order. When I saw the canal it was in excellent repair throughout.

Capacity and average discharge of the canal.

I have estimated the maximum intake of the canal with five and one-half feet of water on the gauge-rod at its head, at 720 cubic feet per second, though its capacity to transmit and distribute, in its present condition, probably does not exceed 600 cubic feet per second. A daily record is kept of the height of water on this gauge, from which I have computed a table of daily discharge for the past two seasons. The following table is a monthly summary of these discharges:

Table of maximum, minimum, and mean discharge of the San Joaquin and Kings River Canal, 1878–79.

MONTH.	Discharge in cubic feet per second.			Total discharge in cubic feet.
	Maximum.	Minimum.	Mean.	
1878.				
January	170.2	0.0	130.7	349,980,480
February	213.2	138.6	154.6	373,973,760
March	213.2	138.6	153.0	409,898,880
April	328.4	138.6	251.8	652,717,440
May	550.7	328.4	522.0	1,398,168,000
June	550.7	550.7	550.7	1,427,414,400
July	550.7	111.0	410.7	1,100,131,200
August	352.3	247.8	294.4	788,616,000
September	271.1	146.6	192.3	499,305,600
October	248.2	146.6	191.8	513,561,600
November	286.8	229.8	256.8	665,668,800
December	237.0	202.0	219.5	587,770,560
1879.				
January	470.3	213.2	265.5	711,262,080
February	445.3	248.2	336.2	813,257,280
March	588.9	398.1	479.7	1,284,793,920
April	576.5	550.7	567.0	1,469,767,680
May	576.5	526.0	550.2	1,473,681,600
June	526.0	372.9	421.7	1,093,098,240
July	498.7	328.4	355.5	953,156,160

The table shows that the maximum discharge during the whole period of nineteen months, did not exceed 590 cubic feet per second, or 82 per cent. of its intake capacity. From the elevation of high water mark in the canal on the sixtieth mile, I calculated the greatest discharge at that point, during the past season, to have been about 170 cubic feet per second.

PRACTICE OF IRRIGATION.

Description of soils.

The lands irrigated by the San Joaquin and Kings River Canal vary so greatly in character that the practice of irrigation is not uniform. From the point where general irrigation first begins, near Firebaugh's, eight miles below the head of the canal, to its terminus at Orestimba Creek, there is a gradual change in the quality, depth, and texture of the soil, from the minimum of absorptiveness, and the consequent maximum number of irrigations required to produce crops, to the maximum of absorptiveness and the minimum of applications necessary. The soils which retain moisture longest are those which absorb most water, and are consequently best adapted for irrigation. In no irrigated section of the State are the extremes in quality of soil more marked. The adobe soils do not extend the entire distance from the canal to the river, but seem to be principally limited to a strip two to five miles wide, from Firebaugh's to Los Baños Creek. They are shallow—from one to two feet deep—and underlaid with yellow clay hard pan. East of this strip to the river, the soil is generally of an alluvial character, highly susceptible of profitable irrigation, but not heretofore provided with facilities for irrigation, the land being devoted exclusively to grazing purposes. On either side of Los Baños Creek the soil is a compact sandy loam for a mile or two in width, very fertile, and well adapted to irrigation. With the exception of three or four miles along the canal where San Luis Creek spreads out upon the plains, the soil for the remaining distance to the terminus is a light brown argillaceous loam, with an occasional admixture of sand. It is thirty to forty feet in depth, compact, fertile, and highly retentive of moisture.

Irrigation periods.

The year may be properly divided into three irrigation periods:

The first period includes the months of October, November, December, and January. More than three-fourths of the area irrigated by the canal is devoted to cereals; the period of greatest demand is therefore that in which these crops require watering. To guard against a dry season, those farmers who own lands which absorb most water and retain it longest begin soaking their fields, prior to sowing grain, in October, continuing through the months of November, December, and January, in some cases postponing this first watering as late as February. On the class of lands referred to, this irrigation is usually all that is required to mature a crop, as with the ground thoroughly soaked, a very slight rainfall of two or three inches thereafter suffices to supply the surface with moisture until the young grain is high enough to shade the ground from the sun. During this period also the shallow adobe soils at the upper end of the canal require their first watering, but as they absorb but a small quantity of water the demand upon the total volume of water in the canal is comparatively light from that quarter. The experience of the past season has taught

the farmers that it is not good policy to defer the first irrigation later than January, and as the water rates for fall irrigation, prior to January, are cheaper than for the season, it is probable that hereafter the season of greatest demand will be in the first period.

The second period includes the months of February, March, April, and May. During this period the grain on the shallow adobe soils requires almost constant irrigation, the number of applications necessary being from four to seven. The soil dries out and the surface bakes so quickly that if it be not flooded every three or four weeks the crop is a failure. This is a season therefore of constant demand upon the canal from adobe lands, which at present constitute nearly one-half of the total acreage irrigated by its waters. In this period alfalfa is irrigated the first and second times, and the general irrigation of cereals is completed.

The third period embraces the months of June, July, August, and September. Irrigation is confined during this period to alfalfa, corn, potatoes, beans, and garden produce. Corn has not yet become an important crop in this section, as it does not thrive on the adobe soils, and the deep loamy soils have not had irrigation facilities long enough to thoroughly test it as a standard product. It has proved a general failure the past season on account of the ravages of an insect which attacked the silk. The preparation of corn land for plowing, by means of a thorough wetting, begins early in this period, or the latter part of the second, and the crop is given one or two waterings thereafter.

These facts appear to show that the season of greatest demand, heretofore in the second period, will shortly become extended more uniformly over both the first and second periods, during which the supply in the river is greatest, and that the season of least demand is during the third period.

Methods of Irrigation.

The check-levee system.

But one system is practiced in the application of water on the lands west of the San Joaquin River—that of flooding the surface with the aid of check levees dividing the land into compartments. The soil does not admit of the use of the seepage method, such as is practiced in the Mussel Slough country and other sandy localities, and the surface of the land is so uniform that the costlier method of flooding by small ditches, which is necessary on rolling ground, has no advantages, and indeed seems never to have been practiced here.

Slope of land.

The general slope of the land from the canal toward the river is from eight to twelve feet per mile, and is remarkable for its uniformity and smoothness. It could scarcely have been better prepared for irrigation than nature has prepared it This is particularly the case on the Dos Palos Ranch, below Firebaugh's, where the smoothness of surface permitted the distributing ditches and check levees to be laid out with the most exact and systematic regularity. The primary ditches are run at an angle of about 45 degrees from the direction of the canal, and are just half a mile apart. This ranch, of 5,000 acres, was first opened by the Canal Company as an experimental farm, to make a practical demonstration of the system of irrigation devised by the engineer in charge. This system involved

a series of secondary ditches extending from the primaries on both sides, with numerous small boxes opening from them into smaller tertiary ditches or plow furrows, running diagonally across the land in two directions, dividing the ground into diamond-shaped plats, 120x150 feet in size.

Old system abandoned.

The experiment proved a disastrous failure, after the expenditure of $50,000, and was abandoned. The secondary and tertiary ditches were removed, and between the primary ditches check levees were constructed on six-inch contour lines, varying in horizontal distance with the slope of the ground, and an intermediate division levee was built midway between and parallel with the ditches. By this method the cost per acre for labor at each irrigation was reduced to 3 cents, where it had formerly cost 33 cents, and it is thought that when gates are constructed in the levees to drain the compartments into those next below, the cost will be still further reduced, as it will save the labor of cutting a hole in the levee and closing it again at each irrigation.

In other parts of the valley irrigated by this canal the check levees are less regular in their alignment, as they follow the contour of the surface, which is generally not quite so smooth as upon the farm to which allusion has just been made, but they present no such winding lines as are necessary in some other portions of the State. The compartments inclosed by the levees generally contain from 8 to 25 acres, seldom more. They are, therefore, quickly filled and drained off again. This is a great desideratum, as it is the aim of the irrigators to keep the water constantly in motion, and perform the operation of wetting the lands and draining them again as quickly as possible, except in the case of dry lands being wetted for the first time, when the compartments are filled to their utmost capacity, and the water is allowed to soak away.

Cost of preparing land.

The average cost of preparing the ground with ditches and check levees is about $1 50 per acre, varying but a few cents either way from that figure. The check levees cost about $12 00 per mile, and are thrown up with a "V" scraper. Three men and 26 animals will build a mile of levee in a day. Their sides are generally too steep to be driven over with farming machinery, which is an objection. Doubtless the extra cost of constructing the levees with broad base and flat side slopes would be amply compensated for by the increased facility attained in the harvesting of the crops.

The duty of water.

Unfortunately I visited this interesting section of the country at a time when general irrigation was over. I therefore saw but little of the actual application of water, and was unable to make any experiments on the quantity of water applied to the different crops upon the various classes of soils. I obtained a general idea of this water quantity, however, by conversation with the irrigators, who were able to state the amount of land they were accustomed to irrigate with a certain quantity of water flowing over a weir with a given depth and length, or other tolerable definite measures which gave me a basis for

calculation of the amount of discharge. From these sources I present the following examples:

First example—The first irrigator under the canal, below Firebaugh's—a tenant on the lands of Miller & Lux—watered 30 acres in 12 hours with 13.5 cubic feet per second, and the labor of one man. This was at the first irrigation of the season; the second required a little less water. The discharge would suffice to cover the land to a depth of 0.45 feet, in the time specified, not all of which was absorbed. Soil, alkaline adobe, two feet deep, underlaid with impermeable yellow hard-pan. Barley required 4 irrigations during the season; wheat, 5. Yield about 20 bushels per acre. Cost of labor, per irrigation, 5 cents per acre.

Second example—Seven miles below Firebaugh's, on the Dos Palos Ranch, 500 acres can be irrigated in 12 hours with a discharge of about 165 cubic feet per second, running in three primary ditches, and with the labor of six men. The average depth of water required would therefore be 0.33 feet over the whole area. [This calculation of discharge over the gates was checked as follows: The compartments next to the main canal will fill in one hour by the discharge of one ditch, carrying 55.54 cubic feet per second. They contain 8 acres, and the discharge 55.54 cubic feet per second would cover 8 acres to an average depth of 0.57 feet in one hour. Assuming that 0.35 feet soaked away there would be left 0.22 feet in depth, or 76,665 cubic feet to pass on to the next check. With this water, in addition to that from the ditch, the next check of 8 acres would fill in 37 minutes, and all the others at that rate, presuming the soil of each to absorb the same amount. The three ditches at that rate would irrigate 523 acres in 12 hours. The two calculations agree so closely that the result may be accepted as a very near approximation to the truth.] The soil is similar to that of the first example. Barley was irrigated five times, wheat six times, and alfalfa seven times during the season. Yield of wheat and barley, 17 to 20 bushels per acre; average cost per acre per irrigation, for labor, 3 cents.

Third example—On Miller & Lux's Canal Farm, thirty-three miles below the head of the canal, and twenty-five miles below Firebaugh's, wheat and barley require three irrigations, and alfalfa three to four. No data could be obtained as to water quantity used. The general soil characteristics are a black adobe, mixed with a little sand, and underlaid with yellow hardpan, one foot below the surface; other parts of the farm are a sandy loam, and the gradations between the two form the bulk of the land. A force of seven experienced irrigators are kept constantly employed, and from April 1st, to August 1st, last season, this force accomplished the irrigation of what would be equivalent to 9,500 acres irrigated once; the average cost per acre for labor at each irrigation being thirteen cents. This cost is much greater than it would be but for the gophers which infest the alfalfa fields and burrow in the levees, weakening them to such an extent that they require a large force to keep them in repair while the water is being applied.

Fourth example—An irrigator in the Badger Flat settlement, near the head of the supply ditch, running through that thrifty community, informed me that with a discharge, which I estimated at 15.5 cubic feet per second, he could irrigate 300 acres in ten days. This discharge, for the period named, would be equivalent to a depth of

1.02 feet over the whole area. The soil is a deep, mellow sandy loam, and has been irrigated for several years. The wheat was all watered once, and part of it twice. Corn was irrigated twice. The yield of wheat was about twenty-one and one-half bushels per acre.

Fifth example—Another irrigator in the Badger Flat settlement uses a head of about six cubic feet per second, with which he can irrigate 100 acres of alfalfa in eight days, the discharge being equivalent to an average depth of 0.95 feet over the whole area. The soil is a compact loam, six feet deep, underlaid with a stratum of black alkaline adobe hardpan, four feet thick. Beneath this hardpan, permanent water is found, having an alkaline taste. Alfalfa is irrigated three to five times a year, water being applied after each cutting. The average cost for labor per irrigation is ten cents per acre.

Sixth example—On Sec. 35, T. 7 S., R. 8 E., near the terminus of the canal, a piece of alfalfa, containing 20 acres, seeded in the fall of 1878, was irrigated in 12 hours, with 17 cubic feet per second, at the third watering of the season, the discharge being equivalent to a depth of 0.45 feet over the whole area. The first time the land was irrigated, it required 36 hours to irrigate 16 acres with about the same head, giving an average depth of over three feet upon the land. The soil is a compact, black, argillaceous loam, closer in texture than the bulk of the land in the vicinity, and dying out more quickly. A well on the premises is 60 feet deep, and, prior to the commencement of irrigation, contained three feet of water. In August last, less than a year after the commencement of irrigation, the well contained 13 feet of water.

On the canal extension, some 8,000 acres were irrigated the past season for the first time, the crop being principally wheat. Irrigation was begun late in the season, the farmers, as usual, deferring preparations in the hope of avoiding the necessity for it. When the certainty of a dry season was pretty well established by the almost total lack of rain up to January 1st, everybody hastened to throw up levees and cut ditches, and began wetting their lands. Those who irrigated but once raised the best crops, the second irrigation, where applied, having the effect of producing rust, lessening the yield, and the quality of the grain. This effect seemed to establish pretty clearly the fact that, on the peculiar class of soils which I have described as commanded by the canal extension, but one irrigation is required to mature cereals. In fact the land is so retentive of moisture, that but little, if any, of the 8,000 acres irrigated the past season will be irrigated the coming season, the farmers feeling confident that even two inches of rain, to sprout their grain, will be sufficient with the moisture in the soil to mature a crop without further watering. In this respect the soil of that section is remarkable, and has no parallel in the State, so far as I know, for its peculiar adaptability to profitable irrigation.

Conclusions—Duty of Water.

The examples that have been cited, and the facts that have been stated, naturally lead to these conclusions on the duty of water:

First—That upon the shallow, adobe soils of the district, the maximum duty of water can never be increased to any great extent, beyond what it is at present. The texture of the soil is such that it does not retain water, and requires no less (as near as can be judged) the fifth year of irrigation than the first. The greatest time between waterings

of cereals is about 25 days, and the depth absorbed at each watering about four inches; the duty of cereals is, therefore, about 150 acres per cubic foot per second, through the season of greatest demand.

Second—That the duty of water upon the deep loamy soils in the lower portion of the district probably does not exceed 30 acres the first year of irrigation, but may reach several hundred in subsequent years.

Third—That the maximum duty of water over the whole canal will be attained under the present system of husbandry only when the district shall have been thoroughly wetted for several successive seasons, and when the crops planted shall be so varied, and follow each other in such rotation, that the demand will be constant and uniform throughout the greater portion of the year.

Fourth—That our data are insufficient, and our observations have covered too limited a period, to form definite conclusions as to the present or the possible future duty of water.

Further estimates on the duty of water.

The amount of land irrigated in 1879 is stated to have been 30,000 acres. Prior to the last season the greatest amount irrigated was but little in excess of 20,000 acres; but it is expected that 50,000 acres will be watered by the canal the coming year. During the first seven months of 1879 the quantity of water diverted by the canal at its head was 7,799,016,960 cubic feet—an average for the period of 425.8 cubic feet per second. The average duty accomplished by the water diverted was, therefore, 70.4 acres per cubic foot per second. The quantity diverted was equivalent to 259,967 cubic feet per acre irrigated, equal to a depth of nearly six feet over the lands watered. The following approximate statement shows, in a general way, the distribution of this water:

8,500 acres received 2.1 feet in six irrigations =	17,850 acres irrigated one foot deep.
4,500 acres received 2.0 feet in two irrigations =	9,000 acres irrigated one foot deep.
3,000 acres received 3.0 feet in three irrigations =	9,000 acres irrigated one foot deep.
*14,000 acres received 5.0 feet in one irrigation =	70,000 acres irrigated one foot deep.
Total equivalent	105,850 acres irrigated one foot deep.

* The first irrigations of deep soils below the extension of the canal probably consumed water to this amount.

Average depth of water probably applied, 3.5 feet over the whole area. These figures would imply a loss in the canal, including the waste from various causes, of over 40 per cent. of the water diverted.

LOSS AND WASTE OF WATER.

The determination of the loss by percolation and evaporation, excluding the question of waste through the waste sluices and at the terminus of the canal, is an extremely complex problem, which I could not attempt to solve. For the first thirty-eight and a half miles—to Los Baños Creek—the character of the bed is such as to preclude the possibility of any appreciable percolation. Beyond that point, however, in the remaining twenty-eight and a half miles, the evidences of great loss by percolation are numerous. The canal extension was used last season for the first time. Shortly after water was turned into the main channel the effect of percolation began to be noticed in the wells of the neighborhood.

Effect on wells.

For five miles below the canal the water in the wells was raised from four to twenty feet, and even thirty feet in some instances. Several wells within a mile of the canal, whose normal water surface was thirty feet below the top, filled up while irrigation was in progress in the vicinity, so that for the time being water could be dipped out by hand. After a few weeks it receded to fifteen or twenty feet below the surface, but its elevation was permanently raised ten or fifteen feet. At the mouth of Orestimba Creek, five miles below the canal along the river, wells were filled four feet.

Effect of percolation above canal.

The effect of excessive percolation is not only noticeable below the canal, but it is traceable for a long distance above it. In one case a well a mile *above* the canal in which the surface of the water has always stood at about forty feet from the top, had filled up to within twenty-five feet of the surface, up to the middle of August last, the last five feet having come in during the preceding two months, showing that the whole country is being saturated, and the general elevation of the subterranean waters is being permanently raised. It is believed that this will continue until the permanent level of the waters is not more than five to ten feet below the surface, unless the canal be so thoroughly puddled with sediment as to stop percolation entirely.

This fact of the saturation of the lower levels of the soil augurs well for the future enlargement of the duty of water.

DRAINAGE.

Great necessity for drainage.

The necessity for scrupulous attention to drainage in connection with irrigation, has forced itself emphatically upon the irrigators along the line of the San Joaquin and Kings River Canal, particularly those who till the adobe soils. The slope and smoothness of the ground is favorable for easy drainage, but nature is assisted by the cutting of ditches from all the low spots where water might be disposed to stand. The effect of stagnant water upon the heavier classes of soils is to destroy its vitality and productive power. Plants grow spindling and die, and the earth bakes in the hot sun with a surface crust like burned bricks.

RESULTS OF IRRIGATION.

Its importance to the country.

But for irrigation, all crops on that portion of the west side commanded by the canal extension, where dry farming has heretofore been exclusively practiced, would have proved a disastrous failure. Above the canal the crops failed almost entirely, while below it the lands irrigated once, yielded seven to eleven sacks per acre (15 to 25 bushels), and with fall irrigation, the same lands are expected to yield much more. The farmers witnessing such results have had their former apathy turned to enthusiasm, and all within reach of the canal are now vigorously preparing to reap the advantages which the opportunities for irrigating their lands affords. Heretofore farming in that section has been a cheerless and discouraging pursuit. It was impossible to have orchards, gardens, meadows, and other luxuries of that nature which make rural life agreeable, and rural homes cheerful

and pleasant. A few farmers had, by means of windmills and pumps, contrived to create a green spot about their homes—a few trees, a small vegetable garden, and flowers; but the generality of the homes were devoid of those evidences of thrift and comfort. With the advent of a canal, and a constant supply of water for irrigation, the farmers are sowing meadows of alfalfa, planting trees and vines, and preparing to live.

SALE OF WATER.

Water sold by the acre.

Water is sold on the San Joaquin and Kings River Canal exclusively by the acre irrigated. Following is the schedule of prices:

For cereals, during any part of the season from July 1st of one year to the same date of the following year, $2 50 per acre.

For alfalfa, $3 per acre per year.

For market gardens, $5 per year per acre.

For wild grass lands, 75 cents per acre per year.

For the irrigation of second crop of anything in the same season, $1.

For the fall irrigation of lands, from July 1st to January 1st, the charge for a single irrigation is $1 50 per acre. After January 1st any number of waterings necessary to mature crops of cereals is given for $1.

Volume of water used unrestricted.

No restriction is placed upon the number of irrigations to be applied or the amount of water to be used, except the general one that the amount shall be the "requisite quantity without waste or excess." There is, therefore, no special incentive to economy in the use of water. Parties requiring water are obliged to give notice in writing, designating the land and the number of acres for which water is requested, signing an obligation to pay for the same. The company's employés alone are permitted to open and close the discharge gates.

A source of waste.

This method of selling water is doubtless less troublesome and less expensive to the canal company than that by measurement, but it must inevitably be a source of waste, and when the full area commanded by the canal shall have come under cultivation, there will arise a necessity for the adoption of every means of promoting economy in the use of water, one of which will be its sale by absolute quantity.

Water for stock.

The Canal Company have a scale of prices also for water for stock. These apply to those who herd cattle in the vicinity of the canal, or to drovers driving their herds through the country. For cattle the charge is $100 per year, or $40 per month for 1,000; for sheep and hogs, $50 per year, or $10 per month per 1,000. The charges for traveling droves are higher.

FALL IRRIGATION.

Farmers whose lands are retentive of moisture have an advantage in being able to mature their crops with the single fall irrigation, which costs but $1 50 per acre. I met one farmer in the Badger Flat settlement, who manages to get several profitable crops from his land

each season with the minimum water bill. He commences to irrigate after July first for corn, potatoes, melons, beans, etc., which produce a good fall crop with one watering. In the winter he sows barley upon the same land, usually cutting it for hay, sometimes getting two crops from the same stand, all of which was matured by the moisture remaining in the soil from the fall irrigation, supplemented by whatever rainfall there may have been. He thus obtains two or three crops a year with but one watering.

COST OF CROPS.

The cost of producing a crop of barley on the alkaline adobe lands of the Dos Palos Ranch is given as follows:

Plowing, per acre	$1 00
Harrowing and seeding, per acre	50
Seed, per acre	60
Five irrigations, (labor), per acre	15
Five irrigations, (water), per acre (special contract)	1 25
Heading and stacking, contract price, per acre	1 25
Threshing, at 10 cents per 100 lbs, say	1 40
Sacks	1 40
Total	$7 55

The cost of a wheat crop is slightly in excess of this amount, in the items of seed and labor of irrigation.

The cost of a wheat crop on land near Hill's Ferry, the first year of irrigation, was given as follows (yield 15 centals per acre):

Plowing and harrowing, per acre	$1 50
Seed, bluestone, and sowing, per acre	1 00
Two irrigations, (water), per acre	2 50
Two irrigations, (labor), per acre	75
Heading and stacking, per acre	1 25
Threshing, (15 centals at 10 cents), per acre	1 50
Sacks, per acre	1 25
Total	$9 75
Cost of delivering on river bank at Hill's Ferry	1 50
Total cost delivered at market	$11 25
Value of crop at Hill's Ferry, $1 50 per cental	22 50
Profit	$11 25

RENTAL OF IRRIGATED LANDS.

Miller & Lux have a number of tenants on their irrigated lands who farm them on the following terms: Where the land is prepared for irrigation before the tenant occupies it, he pays one-half to one-fifth of the crop as rent, according to what the owners furnish. If they furnish teams, groceries, feed, and seed, the owners take one-half the crop. If the tenant furnishes everything, he pays one-fifth, the grain to be threshed and delivered. The tenant pays one-half the water bill, receiving the benefit of a special contract made between Miller & Lux and the Canal Company before the canal was built, by which they pay but $1 25 per acre per annum for all water required.

Where the land is not prepared for irrigation, the owners furnish lumber at the nearest landing on the river for necessary buildings and for fencing 10 acres of ground to be devoted to alfalfa. The

tenant erects his own house, and makes his ditches and check levees. He pays no rent the first year, but thereafter the same terms apply as those detailed above. Leases are usually made for 5 years, with privilege of purchase at the end of that time.

DITCH ASSOCIATIONS.

Where a distributing ditch from the canal is made to supply a number of farms, the owners or tenants of which have jointly shared the expense, it has been found expedient to form an association or ditch company of the farmers interested to provide for the maintenance of the ditch and the manner of its use. The first association of this sort was for the Badger Flat Ditch, which conveyed water to the Badger Flat settlement. The ditch irrigates 2,125 acres, is owned by eleven stockholders, is three miles long, and cost $1,000. Annual repairs amount to about $200 a year. The society have a President, and a Secretary and Treasurer, and are governed by a set of by-laws and regulations. Each share of stock represents an acre of irrigated land, and is assessed for whatever repairs are required. Should any stockholder enlarge the area of his irrigation, he is required to take more shares of stock, and be assessed thereon pro rata, or should he wish to abandon the irrigation of one tract temporarily, and irrigate the same area elsewhere, he must take stock representing the new lands irrigated. These regulations appear to work harmoniously, and to prevent the misunderstanding and bickerings that arise in such cases without an organization.

Other organizations of that sort are being formed.

Cost of works.

The cost of the main works up to this time has been stated to be $1,300,000, and the maximum capacity of the canal to distribute for irrigation, 600 cubic feet per second. Should the duty of water ever reach as high a figure as 200 acres per second-foot diverted from the river, the cost per acre of the land irrigable with the maximum supply (120,000 acres) will be but $10 80 per acre.

THE CHOWCHILLA CANAL.

Description.

This canal is derived from the right bank of the San Joaquin River, at a point about two miles above the mouth of Fresno Slough and the head of the San Joaquin and Kings River Canal, and follows a general northerly course for 30 miles, terminating at the Chowchilla Slough, on the Chowchilla Ranch. It runs nearly parallel to the river, and five to eight miles distant from it. It was constructed in 1872, by Miller & Lux, owners of the Columbia Ranch, and W. S. Chapman, then owner of the colossal property known as the Chowchilla Ranch, now owned by the Bank of Nevada, and was originally designed rather to furnish water for stock than for purposes of irrigation. The canal, on its whole course of 30 miles, passes over no other lands than the two great ranches named, and as these are devoted exclusively to stock raising, the irrigation from the canal is principally confined to the watering of grasses. For the first two miles from the river the canal occupies the bed of an old slough, whence it

is diverted into an artificial channel 30 feet wide on bottom, 2½ feet deep, with side slopes of 1½ to 1. Its maximum capacity at the head of the canal proper is 110 cubic feet per second, although much more than that may be diverted from the river—the surplus escaping from the slough before reaching the canal. The excavation of the bottom having proven to be very expensive, on account of a tough stratum of sandstone hardpan underlying the surface at a depth of one to two feet, the channel was narrowed, after the first mile or two, to 25 feet on the bottom, the width gradually diminishing to the end, where it is contracted to a width of 15 feet, the depth having also been reduced to 1.5 feet. Its capacity at the lower end is about 25 cubic feet per second.

Difficulty in building substantial headgates.

The treacherous character of the quicksand bed at the head of the canal has made it an exceedingly difficult task to construct a headgate that would withstand the action of floods. For four successive seasons after the building of the canal the headgate was washed out and as often replaced by a new structure, on a different plan.

The present headgate.

In the fall of 1877 the present structure, which has withstood severe tests, and gives every evidence of permanence, was built. As this structure has some novel features, and its plan is indorsed by its success, it deserves a brief description. The use of sheet piling, generally considered indispensable to the safety of structures of this kind, was in this instance abandoned. The foundation was prepared by spreading a layer of loose sandstone, one to two feet thick, evenly laid on the quicksand. Upon this a floor of two-inch plank, without sills, was laid across the axis of the canal, to which was spiked another layer of plank laid lengthways. This floor was placed six feet below the level of the bed of the river, and upon it was built the structure of 10x10 timbers, having a length of 60 feet, a width of 23 feet, and a height of 10 feet of clear water way. The whole was weighted with an embankment of earth, 10 feet high, placed on top of the structure, the weight exceeding 500 tons. The sluiceways or regulating gates were placed five feet from the upper end of the floor, the space of five feet in front being occupied by a box of heavy timbers filled with rock and floored over, the top being one foot below the bed of the river. The water comes into the canal therefore with a free overfall of five feet. In lieu of heavy, solid regulating gates, which are difficult to raise and lower, loose planks five feet long, placed in grooves in the vertical posts, are used. They are removed by a double hook which engages on an iron pin passing through the planks and projecting two or three inches on each side. A rope and windlass assists in raising the planks to the top. The cost of this structure was $3,200, of which $2,000 was expended in laying the foundation.

Cost of canal.

The total cost of the canal was, in round numbers, $100,000. The tough character of the excavation the greater portion of the distance, rendering the free use of blasting powder necessary, greatly increased the cost over that of ordinary earthen channels of like dimensions.

Peculiarty of location—crossing the drainage of the country.

The peculiar location of the canal has rendered it a difficult one to maintain in repair. The drainage of the mountains and plains to the east of the canal, through Sycamore Slough, Mariposa Creek, Fresno River, Berenda Slough, and the Chowchilla, in flood time, spreads over a wide expanse of country on nearing the rim, and seeks an outlet to the San Joaquin directly across the path of the canal, through numerous shallow channels. This surplus flood water, as well as that from the overflow of the San Joaquin, above the head of the canal, has been wont to sweep across the low banks thereof with little to check it. This is still in great measure unprovided for, although at the crossing of the larger channels outlet gates have been erected on the lower side of the canal. At the time of my visit, the lower or left bank had been restored where washed away by the last floods, but the embankment on the upper side is still wanting for long distances, and through these breaks the water passes freely, causing large shallow ponds, covering hundreds of acres. The loss by percolation is nominal, owing to the impervious nature of the bed, but that by evaporation must be considerable.

PRACTICE OF IRRIGATION.

Irrigation on the Columbia Ranch.

The successive destruction of the headwork rendered the canal of little service during the first four years of its existence. But little land was cultivated on the Chowchilla Ranch during that period, and the irrigation of it was supplemented by the periodical flow of the Chowchilla River. On the Columbia Ranch no land was irrigated, but in 1877 artificial watering was inaugurated by an experimental irrigation of natural grasses. The season was dry and food for cattle scarce. The summer flooding of wild grass gave it a fresh and vigorous start, and the experiment proved so successful that it was continued on quite an extensive scale. Check levees were thrown up for controlling the water, and a rude system introduced. In 1879, 13,000 acres were irrigated, of which 1,800 were of alfalfa and barley, and 1,200 acres of wild grass were watered directly from the canal proper, and 10,000 acres of wild grass from the slough—the water being diverted above the lower headgate or regulating bridge of the canal, two miles from the river. The 3,000 acres irrigated from the canal are prepared with well constructed check levees 0.5 feet apart in vertical height, conforming to the contour of the ground, and dividing the land into compartments of 20 to 50 acres. Water is conveyed to these by four lateral canals, 8 to 12 feet wide on the bottom, and having a total length of 12 miles.

The average cost of preparing this tract for irrigation is stated to have been two dollars per acre. The land has very litttle slope and the surface is exceedingly irregular. As the soil is of a very firm texture, and underlaid by an impervious substratum, it absorbs a small amount of water and retains it pretty well, but the most careful attention must be paid to its drainage. Fortunately there are deep sloughs intersecting the ranch, into which the surplus waters from the lands may be drained and carried off to the river. The distance to permanent water is generally but six to eight feet, underneath a stratum either of clay or hardpan, and it is not affected in height by surface irrigation.

On the well prepared land two men, working alternately day and night, can irrigate 100 acres in 24 hours, at an average cost of three cents per irrigation. Of the quantity of water required, I could form no estimate, as irrigation was not in progress at the time of my visit, and all the lateral canals were dry. Two irrigations only were applied to the lands the past season.

One serious fault in the irrigation of the Columbia Ranch presented itself, and that was that cattle were allowed to occupy the meadows while they were being irrigated. As the land drained and dried off, it was left in a wretched condition, as may be readily imagined of that stiff character of soil.

Irrigation on the Chowchilla Ranch.

At the terminus of the canal about 1,400 acres are irrigated on the Chowchilla Ranch. One thousand acres are well set in alfalfa, and the remainder was this year devoted to barley preparatory to sowing it also to alfalfa the coming season. The soil of the Chowchilla Ranch, or that portion of it which is irrigated, is of a very different character from that of the Columbia Ranch. It is alluvial in its composition, consisting of a fine sandy loam of considerable depth (15 or 20 feet), and containing a great deal of mica. It is very favorable soil for irrigation, and is irrigated in the same manner as that just described as in vogue on the Columbia Ranch—by the flooding of the surface. An expensive system of check levees and regulating gates has been made. The slope of the ground is somewhat irregular, and the levees have no uniform direction, but follow in winding lines the contour of the surface. They are from two to three feet high, with side slopes so nearly vertical that it is difficult to ride on them on horseback, and they form impassable barriers for farming machinery. The gates through the levees for draining water from one compartment to another were originally so designed as to be used for a roadway for farm wagons; but this absurd and expensive arrangement has been abandoned, and other means of passing across the levees have been devised. These compartments inclosed by the levees have an area of 20 to 100 acres, and take water from one side only. The fault of the system seemed to be that the compartments were too large. The discharge of the canal is so little, and so great a length of time is required to fill the larger compartments sufficiently to cover the highest ground, during which the water must stand on the lowest ground, that it has an injurious effect upon the alfalfa, particularly in hot weather. There were numerous bare spots in these large checks, where the alfalfa had been killed out—scalded by the sun and water. With small checks, of say ten acres in area, irrigation is much more rapid and effective, and is performed with greater economy of water.

The usual discharge of the canal at its terminus during the summer season is about 15 cubic feet per second. With this head of water one man can irrigate 25 to 30 acres of alfalfa in 24 hours; say two acres a day per cubic foot per second, the flow being equivalent to an average depth of 12 to 14 inches over the land. About one-half this is absorbed, and the remainder is drained out into a lower and adjoining compartment. The cost per acre for labor of irrigation is about three cents for each watering. But two waterings were given during the past season—one in May, the other in August. Two crops

of hay were cut up to August 1st, and the meadows were pastured the rest of the season.

At the Ranch House 10 or 20 acres of garden and orchard are irrigated, partly from the canal and partly from artesian wells.

The duty of water.

Assuming that alfalfa requires but two irrigations in the period from January 1st to August 1st, and that one cubic foot per second is equal to the duty of two acres a day, it would reach a total duty of 212 acres in the period specified.

Our tables of canal discharges, based upon gaugings and a daily rod record, show that for the period named the average discharge of the canal at its head was 57½ cubic feet per second, with which the irrigation of 4,400 acres was accomplished, giving an average duty of but 76½ acres per cubic foot per second. The water must, therefore, have been idle a considerable portion of the year, and allowed to run through the canal only for the use of the immense herds of cattle which are maintained on the ranches through which it passes.

The land adjacent to the canal for 10 or 15 miles in its center, is worthless for agricultural purposes. The sandstone hardpan lies but a few inches below the surface, and the soil is too thin and poor to support anything but a scanty growth of grass. Near the river there is considerable land highly susceptible of irrigation, which could be irrigated by the canal, but I can form no estimate of its area.

Artesian wells.

The abundant supply of artesian water which has been obtained on the Chowchilla Ranch is a subject of interest, in the consideration of the water supply for a section of country requiring irrigation. A flowing well at a farm house is a luxury which requires no argument to enforce its appreciation. As supplemental to other sources of water supply for irrigation, artesian wells are of value, although they are necessarily limited in their capacity. No fewer than eighteen artesian wells have been bored on the Chowchilla Ranch, of which fifteen have a constant flow. The following table indicates the position, diameter, and discharge of each well, with the depth of a number of them :

ARTESIAN WELLS ON CHOWCHILLA RANCH.

Location, dimensions, and discharge.

Number of well.	Township—south.	Range—east.	Section.	Name or Description of Well.	Depth in feet.	Diameter of pipe, inches.	Flow in cubic feet per second.	Flow in cubic feet per 24 hours.	Flow in United States standard gallons in 24 hours.
1	9	14	20	In north field		6	0.091	7,865	58,642
2	9	14	28, 33	Montgomery line well	190	9	0.100	8,668	64,817
3	10	14	5	At Smith's ranch		6	0.063	5,457	40,811
4	10	14	6	At main ranch house		7	0.067	5,778	43,211
5	10	14	5, 6	In alfalfa field		7	0.100	8,668	64,817
6	10	14	4, 9	In N. E. corner south field		6	0.251	21,669	162,043
7	10	14	16	Montgomery line		8	0.022	1,926	14,404
8	10	14	24	Middle well		6	0.284	24,558	181,918
9	10	15	8	At grove on Ash Slough		7	0.067	5,778	43,211
10	10	15	10	Near Burns' sheep camp		6	No flow.		
11	10	15	10	At Burns' sheep camp		6	No flow.		
12	10	15	16	Little well	233	8	0.007	642	4,800
13	10	15	21	New well	200	6	0.400	34,672	259,270
14	10	15	24, 25	Near Berenda		7	No flow.		
15	10	15	25	Near Berenda	175	7	0.080	6,902	51,613
16	11	15	4, 9	Kentucky well	233	8	0.435	37,560	280,875
17	11	15	1, 2	McLaughlin's camp		7	0.134	11,556	86,422
18	11	16	29	Francisco well		7	0.100	8,668	40,811
				Total			2.2		

The water of these wells is allowed to collect in pools or run off at will. They were bored and are used exclusively for stock purposes, and add greatly to the value of the ranch on this account.

They are within an area of 60 or 70 square miles, the belt having a general northwesterly direction and a width of about five miles, extending from near the railroad to the San Joaquin River. It is a singular fact that although flowing wells have been obtained east of the San Joaquin River at intervals throughout the valley, but one, so far as I know, has resulted from the explorations that have been made on the west side of that stream. This one is directly opposite the cluster of wells on the Chowchilla Ranch, and has a very feeble flow of less than one gallon a minute, the water being highly charged with sulphur. A well some three miles west of the Chowchilla Ranch and some two miles east of the river, belonging to an individual land owner, is one of the strongest in that section. It was bored in January, 1878, is 297 feet deep, and cost $457. It passes through the following strata, a memorandum of which is given to illustrate the geological formation of that portion of the valley:

Surface soil, sandy loam	2. feet.
Fine sand, streaked with thin layers of clay	98. feet.
Hardpan	0.5 feet.
Sand	95.5 feet.
Hard blue clay	100. feet.
Total	297 feet.

The discharge of the well is nearly one-half of a cubic foot per second. When capped for a few hours it seems to accumulate force,

and after being released flows with redoubled energy for a long time, throwing out lumps of clay weighing several pounds, and rising 5 or 6 inches above the top of the pipe. It now irrigates about seven acres of corn and vineyard, but with a storage reservoir to save up the waste water, it could readily be made to irrigate 75 to 100 acres.

DOS PALOS AND TEMPLE SLOUGH CANALS.

I have now to give a brief account of two other irrigation channels, opened by Miller & Lux, and drawing water from the San Joaquin River on the west side, and my task is done. The channels were originally natural sloughs, breaking out from the river and traversing the Rancho Sanjon de Santa Rita, parallel to the river, and were simply deepened and improved for the purpose of affording water for the irrigation of wild grass lands on the rancho. The upper one heads about five miles below Firebaugh's, and is termed Posa Slough, or Dos Palos Canal. A substantial headgate has been built at the river bank, having a clear opening of 24 feet, divided into four bays. It is 15 feet in height from the floor of the structure to the floor of the road bridge over it. The structure is founded on piles driven into the hardpan bed of the slough, is well protected with necessary wings, and is altogether one of the best constructed works of that kind in the country. The floor of the structure is 3.8 feet below the level of low water in the river, August 9th; and high water mark, inside the gates, showed that the canal had not carried a greater depth of water than 5.8 feet over the floor. A quarter of a mile below the gate the canal has a width of 30 feet on bottom, and 130 feet on top, and a depth of 9.5 feet.

Irrigation commences three and one-half miles below the head of the canal, the land being flooded, and the water controlled by means of rude and irregular check levees.

The Temple Slough, a few miles below Posa Slough, has been treated in a similar manner. A substantial headgate, having a clear width of opening of 16 feet, divided into four bays of four feet each, and a height of nine feet, has been built at the river bank. The floor of the structure is 0.3 feet *above* the level of low water, on the day of our visit, August 9th, last. The canal below the gate has a depth of nine feet, a bottom width of 17 feet, and a width on top of 42 feet. High water mark, on the sides of the canal, showed that it had carried a maximum depth of 3.3 feet. Irrigation begins about three-fourths of a mile below the head of the canal. The land next the river is higher than the interior, so that, although the channels have a great depth near the river, they are comparatively shallow where water is diverted from them.

The total cost of these two canals, including the structures and the excavation of the sloughs, was $7,000.

They irrigated last year an area roughly estimated at 8,000 to 10,000 acres of wild grass land.

Both these channels were dry at the time of my visit.

They can doubtless be made to serve a very useful purpose, with the introduction of system in the preparation and cultivation of lands, particularly the Dos Palos Canal, which is so situated as to divert a considerable stream at the low stages of the water in the river,

without the aid of any dam, wingdam, or other appliance for checking and diverting the current of the stream. The natural banks of the river at that point are firm and hard, resisting erosion, and showing no sign of having materially changed in many years.

For the economical and easy diversion of water, therefore, this canal possesses marked advantages.

The Temple Canal can only draw water during the higher stages, and cannot, without reconstruction and deepening, become as serviceable for irrigation as the Dos Palos Canal.

It gives me pleasure, in taking leave of this subject, to acknowledge the cordial hospitality with which I was received and entertained at the various ranches to which my duties led me in making the general reconnoissance of the country, and the willingness with which I was given the special information sought. These courtesies rendered my work easier and more satisfactory.

Respectfully submitted.

JAS. D. SCHUYLER,
Assistant Engineer.

[APPENDIX E.]

REPORT ON THE WORKS AND PRACTICE

— OF —

IRRIGATION IN YOLO COUNTY.

BY J. D. SCHUYLER, ASSISTANT ENGINEER.

OFFICE STATE ENGINEER,
SACRAMENTO, Cal., December 20th, 1879.

Wm. Ham. Hall, State Engineer:

SIR—I have the honor to submit the following report on irrigation works and practice in Yolo County, as the result of a hurried reconnoissance made under your instructions in August of this year. But one week was allotted to me for this purpose, which was scarcely more than sufficient for me to travel over the ground and become familiar with the general extent and character of the works, and quite inadequate for a study of the details of irrigation or the collection of full statistics thereon. As I was unaccompanied by any assistants, it was impossible to obtain more than a rough approximation of the dimensions and discharge of the several canals which supply water to the districts under irrigation. My investigations were confined to the canals and ditches drawing water from Cache Creek, and although Putah Creek furnishes water for irrigation to some extent, I am unable to report upon the works that may exist in that section.

Cache Creek is the outlet to Clear Lake, which receives the drainage of 420 square miles of the Coast Range of mountains, the total water shed of the creek being 1,024 square miles. The lake has a length of 23 miles, a maximum width of eight miles, and a total area of about 51,000 acres. Its elevation above sea level is 1,300 feet. It forms a catchment reservoir, or receiving basin, serving to lessen the volume of the floods of Cache Creek, which otherwise would pour down its steep slope with devastating force into the valley below.

At flood stages, which are caused solely by winter rainfall and not by melting of snows, the discharge of Cache Creek reaches a volume of 30,000 to 35,000 cubic feet per second. This maximum discharge does not last but a few days after a heavy rain, but through the rainy season the stream, sensitive to every storm, fluctuates constantly. During the spring and summer season the surplus waters accumu-

lated in the lake pass off slowly, the volume of the stream gradually diminishing until October, when the minimum discharge of the year is about 40 cubic feet per second. From Clear Lake Cache Creek passes through a rocky cañon for 30 miles, with an average inclination of 28 to 30 feet per mile. At this distance the hills begin to widen out leaving a valley one to three miles wide, and twenty miles long on either side of the creek, merging into the great Sacramento plains. This hill-enclosed valley is known as Capay, and is one of the most fertile wheat producing sections of the State. From the head of the valley to the village of Capay at its foot, the distance by the meanderings of the creek is 28 miles, and the total fall 267 feet, or about nine and one-half feet per mile. In its further course across the Sacramento Valley, until it is lost in the tule basin, the creek has a slope of from four to six feet per mile. The character of the material in its bed through Capay Valley is a slaty gravel, the sandstone bedrock outcropping at various points. After leaving the foothills the stream widens, having a bed of fine blue gravel, underlaid with clay and quicksand.

DESCRIPTION OF IRRIGATION WORKS.

Moore's Ditch.

The first irrigation canal taken out of Cache Creek was constructed by its present owner, Jas. Moore, in 1856, and is still the most important work in the county. It heads eight miles above Woodland, and was originally eight feet wide on the bottom, six to eight feet deep, with side slopes of one on one. In 1863 it was enlarged to a bottom width of sixteen feet, at which it still remains, although its depth has considerably diminished. The length of the main channel is eight miles, with numerous distributaries that conduct water to the lands in the vicinity of the Town of Woodland. The capacity of the ditch is estimated by the owner at 400 cubic feet per second, but in its present condition it will not, I judge, carry one-fourth that amount. Its original cost was about $10,000, but protracted litigation, in defense of the water right, has swelled the account to an estimated total of $50,000. The area irrigated by the ditch is variously estimated at 12,000 to 15,000 acres, all of which, with the exception of about 300 acres of vineyard, is devoted to alfalfa. The main branches and distributing ditches are owned by the irrigators, by whom they were constructed. The main branch lines, of which there are five, are owned by incorporated companies; the stockholders in each being those using water from the ditch in which they are interested. These branches have a capacity of ten to forty cubic feet per second. The dam by which water is diverted into the canal is a temporary structure made of brush and gravel. The first freshet in the fall sweeps it away, and when the water recedes the canal cannot get its supply until the dam is renewed, which does not occur until the low water in the summer. In 1877 the dam was completed April 16th, in 1878, August 1st, and in 1879, July 25th. All the earlier part of the season, therefore, before the completion of the dam, the irrigators were obliged to do without water when it was most needed. The revenues of the canal are considerable—over $5,000 in 1878, and over $7,000 in 1877; and as the expenses are but light, consisting only of the yearly renewal of the dam, and the salary of a Zanjero during the irrigating season, the property is a valuable one. The yearly cost of renewing the dam is from $500 to $2,500, the greater cost occurring when the work is done in the spring months before the

water has subsided to its lower stage. With a permanent dam, and the assurance of a constant supply of water when needed, the area irrigated would be much greater, as alfalfa is found to be a very profitable crop, and water is in general demand. So great is the demand in fact, that the irrigators, I was told, frequently volunteer to replace the dam in the spring when they most require water, at their own expense; but the owner prefers to manage it in his own way, and takes his own time.

Cacheville Agricultural Ditch.

The second canal, in point of time taken from Cache Creek, was the Cacheville Agricultural Ditch, constructed in the winter of 1859-60. It diverted water from the left bank of the stream upon the plain lands in the vicinity of Cacheville. It was in use for a number of years, but a flood having destroyed the headworks, it was closed, and has now been practically abandoned for ten years or more, although I understand that the water right is still held by a corporation known as the Clear Lake Water Works. This corporation has expended considerable capital in the construction of irrigation works from Cache Creek, the principal one being known as the Capay Valley Ditch.

Capay Valley Ditch.

This ditch diverts water from the right bank of Cache Creek, at the head of Capay Valley. It was begun in 1871, completed to its present terminus in the fall of 1873, and water was first turned in May 14th, 1874. Its total length is about 11 or 12 miles, but only about eight miles are now in use. It was started with a bottom width of 24 feet, but after the first half-mile it was narrowed to a width of 16 feet, and at the end of the third mile again contracted to eight feet. The lower end of the ditch was widened to 10 or 12 feet on the bottom. Indeed the ditch seems to have been characterized by a total lack of system in its construction. The flumes, of which there are six, crossing small tributaries of Cache Creek, are quite as devoid of regularity as the dimensions of the earthen channel. They are usually four feet deep, and vary in width from 8 to 16 feet. They were constructed, strange to say, of Oregon fir throughout, a timber of great strength, but poorly adapted to structures that are alternately wet and dry. As a natural consequence the flumes have decayed rapidly, and are now wretchedly out of repair. At the time of my visit, about eight cubic feet per second was entering the head of the ditch, of which three-fourths was lost in the first seven miles, by leakage in the flumes.

The cost of the work is said to have been about $25,000, for which great amount there is indeed little to show. The investment must have been a very unprofitable one, as the yearly revenues are but $350 to $500. The total area under irrigation is now but 280 acres, owned by five different irrigators, all of which is in alfalfa. This area is diminishing yearly, as the ditch becomes more out of repair and its capacity is decreased. Indeed, considerable alfalfa has necessarily been abandoned and died out from lack of water. There is no encouragement, therefore, for farmers to extend their operations, as they would be glad to do were the supply of water maintained.

As originally projected, the ditch was intended to irrigate the whole

of the Capay Valley, on the south side of Cache Creek, an area of some 13,000 acres. Its headworks are admirably located for the easy and safe admission of water.

The old channel, into which the water is diverted before reaching the headgate, has considerably less fall above the headgate than the creek proper. An earthen dam thrown across it to the highest part of the rocky bar turns the water into the canal. A sluice, 4 feet square, beneath the dam serves as an outlet for sand clearance, when required. Water is directed into the old channel by means of a brush dam made of tree tops, weighted with bowlders, which is replaced every year. The cut at the headgate is 19 feet deep, in cemented gravel and bowlders. into which the structure is well embedded. The headgate is framed of heavy timbers, is about 16 feet high, and although the regulating gates are excessively ponderous and difficult to handle, the structure forms a very solid bulkhead against the flood encroachments of the stream.

Water supply.

The water supply at the head of the ditch is exceedingly variable. The flood discharge of the creek has been approximately stated at 35,000 cubic feet per second, but in some seasons, as in 1871–'73–'75 and '77 the creek ran dry at this point from about September 1st to the middle of January of the following year, the diminution beginning in July so seriously as to cut off the supply for irrigation. Notwithstanding this fact, however, the supply at the head of Moore's Ditch is stated to have been constant. In dry seasons the water sinks entirely out of sight for miles together, reappearing and sinking again, according to the nature and depth of the substrata. The supply for the Capay Ditch is therefore precarious, and its value, as a means of supply for lands commanded by it, is apparently slight unless it be supplemented by water stored in Clear Lake, or some other convenient reservoir. The corporation before mentioned—The Clear Lake Water Works—attempted to increase the storage capacity of the lake for this and other purposes by erecting a dam at the outlet, but the measure met with violent opposition from the land owners on the borders of the lake whose estates were inundated by the increased elevation of the lake surface, and the dam causing the trouble was destroyed by them. It is possible that the same purpose may be effected less objectionably by deepening the outlet to the lake several feet, permitting it to be drained off to a lower level each year, and allowing it to be filled in flood season only to the maximum height it naturally reaches. But as I made no examination of the lake I am unprepared to discuss this question, although it is one having an important bearing on the future development of irrigation in Yolo County.

Two proposed canals.

In addition to the dam spoken of and the Capay Ditch, the Clear Lake Water Works began another work, which, as projected, was the most comprehensive scheme for the disposal of the waters of Cache Creek ever attempted. It contemplated the construction of two large canals, taking their head at a point some three miles above the Village of Capay, the one to irrigate the plains on the north of Cache Creek, the other to cover the lands south of that stream. The latter was to have been navigable, and to extend to deep water in Suisun Bay, or elsewhere. At the proposed head of the canals a dam was

constructed six hundred feet in length. It was made prismoidal in form, 15 feet wide on top, with the upper slope of ½ on 1, and the lower 1 on 1. The south half of the dam was about 8 feet high, and the north half about 13 feet. It was constructed of heavy timbers, bolted to the sandstone bedrock which there cropped out in the channel, and the interior was filled with rock and gravel. The dam is reported to have cost $50,000. It still stands firmly in position, but the creek has washed out broad channels on each side of it, leaving the dam on an island. The canals were never begun. In all these various improvements the Clear Lake Water Works have expended some $150,000, but thus far there have been few satisfactory results from their investment.

The Cottonwood Ditch.

Half a mile below the dam last described, a ditch, owned by the Cottonwood Ditch Company, is taken from the right bank of Cache Creek, passing through the Village of Capay, and terminating on the Gordon Rancho, a short distance north of the Town of Madison. Its total length is about ten miles; bottom width, 12 to 15 feet; depth, 2 to 3 feet; slope, 2 feet per mile; maximum capacity, 30 to 40 cubic feet per second. The cost of the works is stated to have been $25,000 to $30,000. The ditch now irrigates about 200 acres, mostly alfalfa. At the time I saw it I estimated its discharge roughly at 10 cubic feet per second. The ditch is in excellent repair, and well maintained. The position of its headgate was well chosen, and it is a substantial structure, some 14 feet in height and 12 feet wide. Water is admitted by means of three vertical gates, which are ponderous and difficult to move. No permanent dam has been built, but water is diverted by a temporary embankment of bowlders, two feet high, into a channel leading to the headgate. I did not learn the date of the construction of this ditch, but it has the appearance of being but recently built, although the company was incorporated in 1870.

Adams Ditch.

Opposite the Village of Capay another ditch is taken from the creek, on its left bank, for the irrigation of lands belonging to D. Q. Adams. The ditch is two and a half to three miles long, 10 feet wide on the bottom, and will carry about two feet depth of water. It supplies water for the irrigation of 20 acres of Chinese gardens, and 200 acres of alfalfa. Its cost could not be ascertained, as the labor was performed by Mr. Adams in the intervals between farm work, and no account was kept of time required.

Minor ditches.

Two other ditches are in existence deriving their supply from Cache Creek, but as they receive water only when the creek is at its higher stages they are comparatively unimportant. One of them, however, is quite novel in its construction, and attracts attention from the original manner in which it takes water from the stream. It was designed by Benj. Peart for the irrigation of his alfalfa, and consists at its head of a circular iron pipe, 30 inches in diameter and 100 feet in length, connecting with the stream at an elevation of nine feet above the bed of the creek and 11.6 feet below the top of the bank in which it is buried to that depth. The slope of the ground from the immediate bank of the creek is so great that in a distance of 3,000 feet

the grade of the ditch connecting with the pipe comes out upon the surface of the ground, the ditch having a fall in that distance of nine inches, and the ground a fall of 12½ feet. The cost of the ditch, including 100 feet of pipe, 300 feet of 4x4 covered flume, and 2,600 feet of excavation, was about $2,000. There must be a depth of at least ten feet of water in the creek before the ditch can receive its supply, but as that is sure to occur at least once in the season, and the creek is often bank full, the ditch proves highly serviceable, especially as one irrigation per annum is quite sufficient to maintain the growth of alfalfa, for which it is solely used. Water is quite as desirable for the drowning of gophers, which attack and destroy the roots of alfalfa, as for the actual nourishment of the plant. But for the gophers alfalfa would flourish well, as the surface water stands at a depth of but three to four feet below the top of the ground, but it would soon be destroyed without water to flood the land and drown the pests. One hundred acres is thus flooded by this ditch, and it commands 300 acres altogether. It was built in the summer of 1877. The point at which the head works are located is about 500 feet below Nelson's Bridge northwest of Woodland.

The only ditch remaining to be described of the Cache Creek system, and the one lowest on the creek, heads on the left bank, at a point about one mile below the bridge of the Woodland and Knight's Landing Railroad. It was constructed and first used in 1864, when about twenty acres of grain were irrigated. It has never been used to any great extent, although it commands about 1,000 acres of excellent irrigable land. It is now out of repair and not in condition for use. As the supply of water is said to be considerable at this point as late as June each year, the ditch might be made very serviceable. At its head there is an underlying stratum of clay in the creek bed at a depth of but four feet, which brings the water near the surface. To force all the water to the top, a double row of sheet piling, about forty feet apart and 100 feet long, has been driven into the bed of the creek, covered with a floor even with the surface. In connection with this arrangement was a low, movable dam, intended to be raised during low water and removed when the floods came.

Three headgates have at different times been erected, but they are all now badly damaged and out of repair. The cost of these works could not be ascertained, but it must have been $4,000 or $5,000.

METHODS OF IRRIGATION PRACTICED.

The check levee system.

The character of the soil in all the irrigated districts of Yolo County, so far as my observations extended, is very uniform—a somewhat stiff, compact loam, of a depth of five to twenty feet. Irrigation by seepage is impracticable, and the flooding of the surface is everywhere practiced. The method of preparing the land for irrigation is the same in all parts, namely, the construction of low check levees or embankments inclosing areas of varying dimensions, according to the slope and contour of the ground. In the section about Woodland, irrigated by the Moore Ditch, the surface of the ground is so smooth and the slope so regular that the preparation of the land is simple, and the checks may be made in uniform squares. The cost of checks and ditches is from $3 50 to $5 per acre. In applying water the checks are allowed to fill to their utmost capacity, and all that is

applied is left to soak away. The system of drainage from one check into the next below is not common. The ditch delivers water so late in the season that by the time it is received the lands are very thirsty and absorb a great deal, while the gravel substratum, which generally underlies the country, affords all the drainage required.

The cost of preparing land with checks and ditches near Madison, under the Cottonwood Ditch, was about $10 an acre.

In the Capay Valley, where the ground has a slope of 50 to 75 feet per mile towards the creek, the cost is greater, reaching as high as $15 to $20 per acre. One large tract at the terminus of the canal, where the slope was not so great, was prepared at a cost of $10 per acre.

MEASUREMENT AND SALE OF WATER.

Water rates—Moore's Ditch.

Water is sold from Moore's Ditch by the cubic foot per second, the price being $4 per foot per second for 24 hours' run. As there is no method of measurement except that of a given area of cross-section without regard to velocity, the amount actually delivered is very variable, but generally exceeds the supposed quantity considerably.

Water rates—Capay Ditch.

The price of water on the Capay Valley Ditch is $1 25 per acre for the first flooding each year, and 50 cents per acre for each subsequent irrigation during the season. These are the only ditches from which water is sold.

COST OF IRRIGATION PER ACRE.

Under the Capay Ditch the cost per acre is dependent solely upon the number of irrigations supplied. One watering is sometimes considered sufficient, and in that case the cost would be $1 25 per acre. Two, and sometimes three, or more waterings are given, it being customary to irrigate the alfalfa every time it is cut when water can be obtained.

In the section about Woodland, irrigated by Moore's Ditch, the cost per acre for irrigation ranges from $1 to $3, according to the amount of water applied, and the average cost for labor is from 20 to 30 cents per acre for each watering. Water is seldom sufficiently abundant to admit of more than one irrigation per annum. This is given as soon after the admission of water in the ditch as possible, which is sometimes as late as October on some of the lands.

CROPS IRRIGATED.

Alfalfa irrigation.

The rainfall is sufficient to produce one good crop of alfalfa in the spring, and the roots, which penetrate to a great depth, find moisture sufficient to maintain a slow growth during the summer; but after the first irrigation it takes a fresh start and grows with wonderful rapidity. Were the water supply furnished regularly through the season, not only would a much greater area be sown to this valuable forage plant, but that now under cultivation would be more frequently watered and produce more abundantly. With a scanty supply of water alfalfa grows slowly, and the stalk is fibrous and tough, but with sufficient moisture it becomes succulent and tender, and grows so vigorously that from five to seven crops may be cut from it

in one season. An instance was related to me in which a certain tract near Woodland yielded a net profit of $71 per acre per annum.

Vineyard irrigation.

Vineyards are thoroughly irrigated in November or December, to prepare the vines for a full fruitage the following season. I was told by Mr. R. B. Blowers, one of the most successful viniculturists in the State, that he would like to irrigate his vineyard in May or June, if he had the water, "not so much," he said, "to assist the growth of the vines as to encourage the birds to stay about the vineyard to destroy grasshoppers and other insects which prey upon the fruit." He estimates his losses, this season, at $1,000 to $2,000 from this cause, on his forty-acre vineyard, and he is now preparing to erect pumping works for maintaining a supply of water in the ditches "for the use of the birds."

DUTY OF WATER.

I could form but little idea of the duty of water in the Yolo District in the short period of my stay. One opportunity was afforded me, however, of making an estimate of the amount absorbed by the soil at an irrigation. A tract of ten acres of well prepared land in alfalfa was irrigated thoroughly in fifteen hours, with a discharge which I measured accurately through an orifice under pressure, and estimated to be 16.4 cubic feet per second, sufficient to have covered the land to a depth of two feet in the time specified. The land had been given a slight wetting three weeks before, when the ground was bare, and the alfalfa at the time of the second wetting was a foot high all over the ground. Were but one watering given in the four months, July, August, September, and October, that water is generally furnished by the ditch, a cubic foot per second would at this rate be equal to the duty of 120 acres.

EFFECT OF IRRIGATION ON SOIL AND CLIMATE.

I found throughout the section visited a general prejudice against the irrigation of grain. Those who had tried it found that the soil was too stiff, and when irrigated in the spring time the land became baked and soured. This experience points at once to the probable cause, a lack of proper drainage, the neglect of which on all heavy soils is sure to produce the results complained of. Alfalfa, however, shades the ground and protects it from the baking sun, although it undoubtedly requires drainage on adobe soils quite as much as other crops. It is stated, also, that wherever tried the irrigation of grain produced an ill effect upon the climate, causing malarial fevers, etc. No effects of that sort are noticeable from the irrigation of alfalfa.

CONCLUSION.

In concluding my account of the irrigation works and practice in Yolo County, the investigation of which interested me exceedingly, I cannot but express the surprise, which in traveling over the country constantly recurred to me, at the comparatively slow progress which has been made in the development of the art of irrigation during the twenty odd years since its first introduction, and

the regret that the large amount of capital which has been expended should have achieved so little. The field is certainly a most promising one, and all the conditions are of the most favorable character for the perfection of a grand system of agriculture by the artificial use of water. Even to the limited extent, and under the discouraging circumstances that irrigation is now practiced, it has proven highly profitable to the irrigators and a boon to the country.

Respectfully submitted.

JAS. D. SCHUYLER,
Assistant Engineer.

REPORT

OF THE

STATE ENGINEER

TO THE

Legislature of the State of California--Session of 1880.

Part V.

SACRAMENTO:
STATE OFFICE : : : : J. D. YOUNG, SUPT. STATE PRINTING.
1880.

REPORT.

PRESENT CONDITION OF THE INQUIRY.

To the Legislature of the State of California:

In the First Part of this report I have sketched an outline of the objects held in view in the prosecution of the work of this department, and have given a brief history of operations up to the end of the past year.

In Parts II, III, and IV, reports concerning the investigations thus far made with respect to the drainage, debris, and irrigation problems have been made.

In this, which is intended to be the closing part, I place before you, as required by the law, a statement of "the present condition of the inquiry" with which I am charged, and make some suggestions for its future conduct.

Should you glance through the general description of country embraced within the field of inquiry gone over by this department, consider the character of the investigations undertaken, and reflect that such work can only be prosecuted gradually, as the changing seasons present the phenomena and results to be observed (explained in Part I), you will, I hope, appreciate the facts announced at the close of chapter one, of Part II, to wit:

"The data so far obtained are now barely brought into form for study;"

"The systemization of observations but just accomplished;"

"The knowledge of localities and present conditions only now acquired," and

"Necessarily the results" thus far attained "are largely preliminary in character."

The knowledge sought for.

For an understanding of the problems presented to this Department at the outset of the work, the first thing required was an engineering knowledge of the field. It was necessary to have good general maps for guidance in field investigations; to have special maps and profiles, showing accurately large scopes of country and the gradients thereof, as a basis for office study of the general problems taken up; to have local, large scale maps, and sections, upon which to plan, project, and estimate quantities and possible results; to have tabulated exhibits of dimensions and gradients of channels, formulated data of the various observations made in studying the physical phenomena of the field, and to make comparative statements of results in order that the tendency of existing causes and the possibilities for the future might be realized.

Such maps, profiles, statements, tables, etc., form the basis of engineering study. The geographical, topographical, and hydrographical data which is embraced in them is obtained by survey.

These surveys, once made, need not be repeated except where some change is to be expected, the measure of which it is important to know, as, for instance, changes in the position and depths of streams. By the employment of a large force, such original surveys can be prosecuted uninterruptedly and soon brought to completion, though there are certain seasons of the year much more favorable for the work than others. But the flow of waters in the streams, which can be studied systematically only after the engineering surveys are made, cannot be observed except as it is presented by nature, and the floods of several seasons at least must be measured to obtain a fair idea of average amounts and effects.

Furthermore, the data concerning the use of water for irrigation with respect to the amounts necessary to effect the desired ends, under the varied circumstances heretofore spoken of, can only be collected by continuous observation as irrigation progresses.

It is not only necessary then to have the engineering data obtained by the original surveys, but also to have the knowledge of physical phenomena presented by the flow of waters and the operations of irrigation, before any definite and final conclusions can be had upon the great questions at issue.

What has been Accomplished.

The work which has been done thus far, has produced results as follows:

First—The completion of nearly all of the original drainage surveys necessary throughout the Sacramento Valley and in the San Joaquin Valley, on the lower river as far south as the mouth of the Stanislaus; thus securing a basis of operations over about two-thirds of the field where the drainage and debris problems are to be studied.

Second—The completion of the general preliminary surveys in the San Joaquin and Tulare Valleys for the collection of topographical data necessary in the study of the irrigation problems, to the extent of about one-half of the work to be done.

Third—The completion of the local detail surveys for purposes of gauging the streams and canals of the Sacramento, San Joaquin, Tulare, and Kern Valleys, to the extent of nine-tenths of all to be done.

All of the extended regions where irrigation is now practiced upon any considerable scale have been examined, and good general maps of them have been compiled from original surveys or reconnoissances, and data collected from many reliable sources.

The lands yet requiring irrigation have been preliminarily reconnoitered from the Stanislaus River southerly throughout the San Joaquin, Tulare, and Kern Valleys, and a portion of them—those located more particularly in Fresno, Tulare, and Kern Counties—have been examined closely, with the view of ascertaining their adaptability to irrigation, and determining preliminarily the probable demand for water for irrigation upon them, so that this class of work may be said to be about one-third accomplished in the great valley of the State.

The statistics of irrigation and of the use of water have been collected for one season. The flow of the streams has also been observed for one season.

A good general map on a large scale, of the entire great valley, from

Shasta County on the north to the Tejon and Tehachapi Mountains on the south, is in progress and about one-half finished.

Special and detail maps of all surveys made have been commenced, and are about three-fourths completed.

The San Bernardino and Los Angeles County irrigation has been studied, good general maps of the country made, and the basis laid for a complete irrigation investigation in those counties, as well as in the great central valley of the State.

What remains to be done.

Upon the field thus gone over, it remains to:

1. Complete the drainage surveys in the Sacramento Valley, and extend them up the San Joaquin Valley.
2. Extend the irrigation surveys in the San Joaquin Valley northward from Fresno County through Merced, Stanislaus, and San Joaquin Counties.
3. Prosecute the examination of the soils of dry lands throughout the valley region to be irrigated; to learn their adaptability to irrigation, and the amount of water they will require for that purpose.
4. Continue the observations on the flow of water in the streams, in order that it may be known what supply of water there is available for irrigation, and what quantities of water are to be conducted away in times of flood.
5. Make examinations of the sources, in order that it may be determined definitely to what extent the water supply for irrigation may be developed by storage, and what may be the probable cost of works for that purpose.
6. Make special surveys, in order to determine in every case where the mining detritus may be kept out of the streams; where it may be stored in the cañons to best advantage; where it can be diverted from the cañons; where it can be stored in the rolling low lands bordering the foothills; where it can be conducted into the Tule basins, and then to project plans and make estimates for the works necessary to accomplish these ends.
7. Re-examine from time to time the river beds, waters, and sediments at certain points where special studies are progressing in order that we may know of any changes that are taking place with the lapse of time, and the variation of seasons and flow in the streams, and thus be enabled to foretell what may be expected from any plan of treatment in the drainage of the valleys.

In addition to completing examinations in the portion of the State where work has already been commenced, I suppose that the remainder of the legitimate field of inquiry where operations have not thus far been attempted, is to receive attention. In that event it will remain to:

First—Advance the observations in the matter of irrigation to other sections of the State, where, though less extended in area to be studied in any one district, the lands are equally in need of irrigation, and where, though there are now none of the troubles experienced already in the older irrigated districts, there will undoubtedly be an equal necessity for State systemization in the near future; and,

Second—Extend the inquiry into the flood effects and their causes in other sections of the State, where, though the scope of country damaged may be comparatively insignificant, the claim for State assistance in securing systemization of works is equally just and urgent.

Present Condition of the Department.

There are now in this office much valuable data which have not yet been brought into final shape.

There has been full $15,000 worth of field work done, from which as yet no definite conclusions have been drawn, for the streams have not run full to be observed, and opportunity and time have not been had to work out results from field notes.

None of the primary conclusions arrived at and which are based upon the volume of waters observed or estimated as discharged, by any stream, whether in the study of the drainage or irrigation problems, should be finally accepted without verification.

There is now in my possession upwards of $10,000 worth of stock, consisting mainly of a steamboat, camp-boats, row-boats, wagons, harness, horses, tents, general camp and mess outfits, surveying and philosophical instruments and apparatus, tools, implements, etc. (as per Secretary's report appended), available for the further prosecution of the work.

There are now standing in the field nearly two hundred tide and river gauges, which have cost, in position, upwards of $2,000, and which including the local gauging surveys, to which they are accessory, have cost upwards of $10,000, and from these but one year's service has been had, whereas they should be observed several years at least, in order that a fair return may be obtained from the cost of establishing them.

And there are about $8,000 in the treasury to the credit of the State Engineer for expenses of the operations of the Department to the last of April.

The Future of the Department.

There is at hand what bids fair to be a propitious season for flood observations on the San Joaquin River (where, as yet, none are had), and for observations on water supply for irrigation throughout the State.

If this work is to be continued, parties should be placed in the field at once to observe the flow of the streams, the flood phenomena, and the use of water for irrigation. To do this, the means at hand are not sufficient.

The appropriation which was made was for the two years ending with April, 1880. Of this appropriation it may be justly said that about twenty thousand dollars were on hand for the further prosecution of the work from the first of January, 1880.

Of this twenty thousand dollars about eight thousand are in cash, ten thousand in stock, and two thousand in rods, gauges, and appliances in position in the field.

The eight thousand cash is sufficient to continue this department to the end of the term, but without doing any field work of moment.

The ten thousand in stock, and two thousand in gauges, etc., will then go over into the next term.

It will be a wise measure to enable this Department to continue field operations at once. Valuable time is being lost. I suggest, therefore, that in making further appropriation for this investigation a portion of the moneys—to the extent of the value of stock, etc., on hand to be carried to the credit of the next term—be placed at the disposal of the State Engineer for use during the present propitious season.

I again respectfully call attention to the fact that there is no necessity for additional means to maintain this office to the end of the present term, and further represent that there is a large amount of labor to be done in the office in formulating the data already obtained. To prosecute the office work now on hand will consume the balance of the cash available, and the stock, if retained unsold, will be carried to the credit of the next term, thus making the expenses of operations for these two years twelve thousand dollars less than the amount appropriated for that purpose.

Furthermore, if there are to be any additional facts of moment and conclusions of value to be collected and arrived at before the assembling of the next Legislature, the data must be obtained within the next six months, the first three of which will present the phenomena of the most importance.

The work which remains to be done—including the observations of the streams for two seasons—in the field of operations already gone over, will be less expensive than that already accomplished; but should the field be extended, and should the work of investigation in detail concerning the disposal of mining detritus, and concerning the storage of water for irrigation purposes be undertaken, it must be remembered that the operations necessarily will be on fully as large a scale as heretofore.

The Expenditures.

Analysis of cost of the investigations to January 10th, 1880.

Appended hereto will be found a statement from the Secretary appointed by the Governor to disburse the fund appropriated to meet the expenses of the investigations with which I have been charged. From this statement and reports and details of accounts in this office I make the following exhibit:

Total appropriation and receipts		$100,564 40
Less stock on hand	$10,482 56	
Less cash on hand	8,158 21	
		18,640 77
Expense		$81,923 63

The following is an approximate statement of the cost of the several inquiries:

The drainage investigation	$43,000 00
The debris investigation	14,000 00
The irrigation investigation	22,000 00
	$79,000 00
General expense, unapportioned	2,923 63
Expense	$81,923 63

As to localities to which the work relates, it may be said that of the $79,000 above mentioned, $48,000 have been expended for the Sacramento Valley, in the drainage and debris investigations; $28,500 for the San Joaquin Valley, in the drainage and irrigation investigation; and $2,500 for San Bernardino and Los Angeles Valleys, in the irrigation investigation.

Very respectfully submitted.

WM. HAM. HALL,
State Engineer.

SACRAMENTO, February 1st, 1880.

SECRETARY'S STATEMENT

Of amount and classification of expenditures in State Engineer Department, to January 10th, 1880.

RECEIPTS.

Amount of appropriation	$100,000 00
Received of Miners' Association (joint survey of Yuba Cañon)	300 00
Received of Farmers' Association (joint survey of Yuba Cañon)	122 15
Received from sale of wagon	142 25
Total available cash	$100,564 40

EXPENDITURES.

Paid for services	$63,536 94
Paid for live stock (horses)	795 00
Paid for rolling stock (wagons, harness, etc.)	1,588 60
Paid for camp equipage and cooks' outfits	697 82
Paid for boats and boating outfits	3,682 70
Paid for instruments	1,809 88
Paid for tools and implements	851 86
Paid for material (lumber, iron, etc.)	1,094 60
Paid for construction, repairs, and alterations	1,335 37
Paid for stationery (drawing paper, maps, etc.)	687 38
Paid for traveling expenses and subsistence	5,343 49
Paid for freight and expressage	878 54
Paid for telegrams and postage	303 77
Paid for miscellaneous expenses	976 32
Paid for provisions	5,800 08
Paid for fuel and lights (coal and oil)	855 62
Paid for forage	1,704 89
Paid for office supplies (furniture, etc.)	463 33
Total expenditures	$92,406 19
Balance in hands of Secretary, State Engineer, and Assistants	325 28
Balance in State treasury January 10th, 1880	7,832 93
Total expended and on hand	$100,564 40

PROPERTY ON HAND AND ITS COST.

Live stock (six horses)	$795 00
Rolling and teaming stock, consisting mainly of three light wagons, one buckboard, harness, etc.	1,364 60
Camp equipage and cooks' outfits, consisting of tents, stoves, kitchen furniture, etc.	700 00
Tools and implements	851 56
Boats and boating outfits (steam launch and its outfit)	2,400 00
Two arks, six skiffs, oars, anchors, ropes, chains, etc.	1,290 00
Instruments	1,809 88
Office furniture, drawing implements, etc.	403 50
For construction of apparatus, additions and alterations to boats and instruments, to adapt them to this special service (properly included in their present cost)	868 02
Total cost	$10,482 56

SACRAMENTO, January 10th, 1880.

Wm. Ham. Hall, State Engineer:

SIR: I submit the above as a correct statement of amount and classification of the expenditures of the State Engineer Department to January 10th, 1880, also a statement of property on hand with its cost.

Very respectfully,

G. B. COSBY, Secretary.

REPORT

OF THE

SECRETARY OF STATE,

OF

Stationery Furnished Members and Committees of the Assembly,

TWENTY-THIRD SESSION, 1880.

REPORT.

J. ADAMS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 20	Stationery furnished	08	
February 2	Stationery furnished	4 36	
			$5 42

E. ANTHONY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	33	
January 12	Stationery furnished	3 02	
January 26	Stationery furnished	1 75	
February 11	Stationery furnished	1 46	
February 13	Stationery furnished	55	
			$7 46

J. S. P. BASS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 12	Stationery furnished	2 66	
January 24	Stationery furnished	1 00	
January 27	Stationery furnished	80	
February 21	Stationery furnished	1 75	
March 6	Stationery furnished	19	
			$7 38

A. BENNETT.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 19	Stationery furnished	2 05	
			$3 03

S. BRAUNHART.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	5 10	
January 8	Stationery furnished	2 00	
February 6	Stationery furnished	63	
			$8 08

MAX BROOKS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	3 52	
January 19	Stationery furnished	2 50	
			$7 00

H. R. BROWN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
			$ 98

J. P. BROWN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
March 13	Stationery furnished	8 65	
April 14	Stationery furnished	3 03	
			$12 66

E. BRUNER.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	10 34	
January 8	Stationery furnished	30	
January 16	Stationery furnished	52	
March 8	Stationery furnished	50	
March 10	Stationery furnished	2 02	
March 22	Stationery furnished	82	
March 26	Stationery furnished	5 73	
			$20 58

L. BRUSIE.

1880.			
January 5	Stationery furnished	$ 35	
January 15	Stationery furnished	3 30	
			$3 65

J. BURNS.

1880.			
January 5	Stationery furnished	$ 35	
January 9	Stationery furnished	5 53	
January 15	Stationery furnished	1 77	
February 6	Stationery furnished	63	
February 20	Stationery furnished	76	
April 13	Stationery furnished	10 85	
			$19 89

SEYMOUR CARR.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	7 22	
February 2	Stationery furnished	1 00	
			$9 20

T. H. CARR.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	2 99	
January 15	Stationery furnished	1 89	
February 6	Stationery furnished	1 19	
February 25	Stationery furnished	1 21	
March 2	Stationery furnished	48	
April 13	Stationery furnished	5 64	
April 14	Stationery furnished	74	
			$15 12

W. W. CAMRON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
March 10	Stationery furnished	6 15	
March 13	Stationery furnished	11 14	
			$18 27

T. L. CHAMBERLAIN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	1 59	
January 24	Stationery furnished	2 00	
March 1	Stationery furnished	26	
April 13	Stationery furnished	13 24	
			$18 07

A. L. CHANDLER.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 7	Stationery furnished	80	
February 17	Stationery furnished	71	
			$2 49

W. F. COFFMAN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 15	Stationery furnished	4 81	
			$5 79

C. COLEMAN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 19	Stationery furnished	4 12	
			$5 10

L. F. COOPER.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 7	Stationery furnished	46	
January 8	Stationery furnished	1 72	
January 19	Stationery furnished	1 93	
January 31	Stationery furnished	43	
February 20	Stationery furnished	1 98	
March 24	Stationery furnished	14 50	
			$22 00

H. J. CORCORAN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	6 75	
January 15	Stationery furnished	78	
March 26	Stationery furnished	4 50	
			$13 01

J. F. COWDERY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 10	Stationery furnished	1 70	
January 31	Stationery furnished	59	
February 4	Stationery furnished	35	
February 25	Stationery furnished	30	
April 7	Stationery furnished	32	
April 10	Stationery furnished	80	
			$5 04

W. W. CUTHBERT.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 7	Stationery furnished	2 68	
			$3 66

R. F. DEL VALLE.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 8	Stationery furnished	1 72	
January 14	Stationery furnished	07	
January 20	Stationery furnished	1 51	
			$4 28

D. DIMOND.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 12	Stationery furnished	2 44	
March 11	Stationery furnished	18	
April 13	Stationery furnished	4 23	
			$7 83

R. C. DOWNS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 21	Stationery furnished	3 78	
			$4 76

A. B. DuBRUTZ.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
			$ 98

W. W. DURHAM.

1880.			
January 5	Stationery furnished	$ 35	
January 10	Stationery furnished	4 50	
January 15	Stationery furnished	1 03	
			$5 88

C. L. ESTEY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	1 72	
January 27	Stationery furnished	60	
March 6	Stationery furnished	3 37	
			$6 67

C. N. FELTON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	1 16	
January 22	Stationery furnished	1 46	
February 1	Stationery furnished	36	
			$3 96

C. HARTSON.

1880.			
April 13	Stationery furnished	$2 13	
April 14	Stationery furnished	3 61	
			$5 74

J. R. FINLAYSON.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	3 86	
January 8	Stationery furnished	86	
January 12	Stationery furnished	85	
February 3	Stationery furnished	21	
March 13	Stationery furnished	8 49	
			$14 62

C. N. FOX.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	9 97	
January 9	Stationery furnished	30	
January 21	Stationery furnished	18	
January 27	Stationery furnished	1 30	
March 5	Stationery furnished	70	
March 8	Stationery furnished	18	
March 18	Stationery furnished	86	
April 6	Stationery furnished	15	
			$13 99

THOMAS FRASER.

1880.			
January 5	Stationery furnished	$ 35	
January 8	Stationery furnished	1 43	
January 6	Stationery furnished	63	
April 14	Stationery furnished	2 22	
			$4 63

D. FRINK.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	1 72	
February 9	Stationery furnished	17	
March 29	Stationery furnished	52	
April 13	Stationery furnished	6 96	
			$10 35

P. T. GAFFEY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	33	
January 7	Stationery furnished	5 12	
January 8	Stationery furnished	86	
January 14	Stationery furnished	30	
January 19	Stationery furnished	08	
February 18	Stationery furnished	08	
March 1	Stationery furnished	75	
March 15	Stationery furnished	1 20	
March 20	Stationery furnished	3 47	
			$12 54

S. J. GARIBALDI.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 12	Stationery furnished	32	
			$1 30

H. A. GORLEY.

1880.			
January 5	Stationery furnished	$ 90	
January 17	Stationery furnished	35	
January 27	Stationery furnished	30	
February 18	Stationery furnished	63	
February 19	Stationery furnished	17	
March 14	Stationery furnished	7 32	
			$9 67

P. M. GREEN.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 14	Stationery furnished	2 03	
January 15	Stationery furnished	03	
February 2	Stationery furnished	12	
March 2	Stationery furnished	18	
April 13	Stationery furnished	9 89	
			$13 23

L. J. HARDY.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	6 97	
January 9	Stationery furnished	65	
April 12	Stationery furnished	6 60	
April 13	Stationery furnished	6 46	
			$21 03

J. J. HARRIS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
			$ 98

D. N. HERSHEY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 7	Stationery furnished	2 86	
February 18	Stationery furnished	43	
			$4 27

J. HYNES.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
			$ 98

E. S. JOSSELYN.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
January ------12	Stationery furnished	74	
January ------20	Stationery furnished	1 06	
January ------30	Stationery furnished	1 28	
March -------13	Stationery furnished	1 09	
April --------14	Stationery furnished	7 60	
			$12 75

M. LANE.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 8	Stationery furnished	4 85	
February ----- 6	Stationery furnished	63	
February -----17	Stationery furnished	43	
			$6 26

F. A. LEACH.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 9	Stationery furnished	3 63	
February ----- 6	Stationery furnished	63	
			$4 61

W. R. LEADBETTER.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
April --------13	Stationery furnished	19 58	
			$20 56

J. LEVEE.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
			$ 98

W. B. MAY.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
			$ 98

A. B. MAGUIRE.

1880.			
January 5	Stationery furnished	$ 35	
January 8	Stationery furnished	2 51	
January 9	Stationery furnished	2 00	
April 13	Stationery furnished	12 83	
			$17 69

W. P. MATHEWS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 21	Stationery furnished	2 13	
April 8	Stationery furnished	53	
			$3 64

STEPHEN MAYBELL.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	1 62	
January 10	Stationery furnished	1 14	
January 19	Stationery furnished	1 43	
April 13	Stationery furnished	13 54	
			$18 08

J. J. McCALLION.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	2 22	
January 8	Stationery furnished	1 72	
February 6	Stationery furnished	63	
April 3	Stationery furnished	60	
			$5 52

A. P. McCARTY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 12	Stationery furnished	1 77	
February 26	Stationery furnished	05	
			$2 80

J. J. McCARTHY.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	2 13	
January 9	Stationery furnished	60	
January 12	Stationery furnished	58	
January 14	Stationery furnished	21	
January 15	Stationery furnished	1 12	
January 30	Stationery furnished	2 30	
April 13	Stationery furnished	9 13	
			$16 42

R. McCOMAS.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
			$ 98

J. J. McDADE.

1880.			
January 7	Stationery furnished	$ 5 08	
January 8	Stationery furnished	2 00	
January 12	Stationery furnished	69	
April 13	Stationery furnished	10 45	
			$18 22

E. J. McINTOSH.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 8	Stationery furnished	1 72	
February 18	Stationery furnished	2 19	
March 13	Stationery furnished	10 69	
			$15 58

T. H. MERRY.

1880.			
January 5	Stationery furnished	$ 35	
January 12	Stationery furnished	4 95	
April 8	Stationery furnished	1 25	
April 12	Stationery furnished	5 20	
April 13	Stationery furnished	2 13	
			$13 88

H. A. MESSENGER.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 12	Stationery furnished	2 10	
March 24	Stationery furnished	1 15	
April 13	Stationery furnished	8 62	
			$12 85

L. G. MORSE.

1880.			
January 5	Stationery furnished	$ 35	
January 8	Stationery furnished	2 81	
January 6	Stationery furnished	63	
January 29	Stationery furnished	96	
			$4 75

CHAS. MULHOLLAND.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 12	Stationery furnished	5 63	
February 8	Stationery furnished	18	
			$6 79

J. NELSON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
			$ 98

G. PICKET.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	3 54	
			$4 52

C. G. SAYLE.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
			$ 98

W. J. SINON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 8	Stationery furnished	3 55	
January 9	Stationery furnished	40	
April 13	Stationery furnished	3 91	
			$8 84

D. N. SHERBURNE.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 8	Stationery furnished	1 51	
January 24	Stationery furnished	2 00	
			$4 49

H. Y. STANLEY.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery fnrnished	11 55	
January 12	Stationery furnished	2 12	
			$14 65

C. L. STODDARD.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
January ------13	Stationery furnished	1 98	
January ------21	Stationery furnished	91	
January ------24	Stationery furnished	1 72	
February -----24	Stationery furnished	69	
April --------13	Stationery furnished	2 14	
April --------14	Stationery furnished	1 63	
			$10 05

H. M. STREETER.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
January ------ 7	Stationery furnished	1 51	
January ------10	Stationery furnished	18	
January ------24	Stationery furnished	1 14	
February -----14	Stationery fnrnished	45	
April -------- 5	Stationery furnished	1 85	
April -------- 7	Stationery furnished	53	
April --------14	Stationery furnished	1 55	
			$8 19

J. O. SWEETLAND.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 6	Stationery furnished	63	
January ------ 9	Stationery furnished	4 96	
April --------13	Stationery furnished	8 27	
			$14 21

G. W. TYLER.

1880.			
January ------ 5	Stationery furnished	$3 03	
January ------ 7	Stationery furnished	50	
January ------ 9	Stationery furnished	1 71	
January ------15	Stationery furnished	2 23	
February ----- 4	Stationery furnished	1 10	
March -------30	Ssationery furnished	80	
April -------- 9	Stationery furnished	63	
			$10 00

A. M. WALKER.

1880.			
January ------ 5	Stationery furnished	$ 35	
January ------ 7	Stationery furnished	6 33	
January ------16	Stationery furnished	2 00	
February -----13	Stationery furnished	2 53	
March -------24	Stationery furnished	1 84	
April ------- 14	Stationery furnished	6 44	
			$19 49

G. B. WARD.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	1 72	
February 5	Stationery furnished	2 34	
February 13	Stationery furnished	3 48	
April 12	Stationery furnished	13 59	
			$22 11

M. WASON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
February 14	Stationery furnished	3 16	
April 13	Stationery furnished	3 86	
April 14	Stationery furnished	3 60	
			$11 60

J. WASSON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 14	Stationery furnished	2 55	
March 5	Stationery furnished	77	
			$4 30

C. C. WATTSON.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 9	Stationery furnished	86	
January 21	Stationery furnished	1 20	
April 13	Stationery furnished	4 44	
			$7 48

J. L. YORK.

1880.			
January 5	Stationery furnished	$ 35	
January 6	Stationery furnished	63	
January 13	Stationery furnished	3 99	
			$4 97

J. N. YOUNG.

1880.			
January 5	Stationery furnished	$ 35	
January 7	Stationery furnished	9 64	
January 9	Stationery furnished	83	
January 10	Stationery furnished	38	
January 14	Stationery furnished	35	
February 3	Stationery furnished	97	
March 11	Stationery furnished	38	
March 27	Stationery furnished	1 60	
			$14 50

COMMITTEE ON AGRICULTURE.

1880.			
January ------ 29	Stationery furnished		$22 34

COMMITTEE ON AGRICULTURE, MINING AND MECHANIC ARTS.

1880.			
March ------- 9	Stationery furnished		$2 06

COMMITTEE ON CHINESE IMMIGRATION AND EMIGRATION.

1880.			
February ----- 13	Stationery furnished	$32 15	
February ----- 18	Stationery furnished	2 05	
February ----- 19	Stationery furnished	1 00	
			$35 20

COMMITTEE ON CLAIMS.

1880.			
January ------ 15	Stationery furnished	$ 7 17	
January ------ 27	Stationery furnished	1 11	
			$8 28

COMMITTEE ON COMMERCE AND NAVIGATION.

1880.			
February ----- 3	Stationery furnished	$ 05	
April -------- 6	Stationery furnished	53	
			$ 58

COMMITTEE ON CORPORATIONS.

1880.			
January ------ 20	Stationery furnished	$22 07	
January ------ 21	Stationery furnished	3 20	
January ------ 23	Stationery furnished	42	
January ------ 27	Stationery furnished	4 74	
January ------ 28	Stationery furnished	2 14	
February ----- 2	Stationery furnished	7 24	
February ----- 13	Stationery furnished	6 33	
February ----- 18	Stationery furnished	1 32	
March ------- 29	Stationery furnished	1 49	
			$48 95

COMMITTEE ON COUNTY GOVERNMENTS.

1880.			
January ------ 23	Stationery furnished	$16 02	
January ------ 27	Stationery furnished	10	
February ----- 2	Stationery furnished	2 33	
February ----- 17	Stationery furnished	16	
March ------- 10	Stationery furnished	94	
March ------- 25	Stationery furnished	04	
			$19 59

COMMITTEE ON CULTURE OF GRAPE VINE.

1880.			
March 16	Stationery furnished		$14 62

COMMITTEES ON EDUCATION, PUBLIC MORALS, AND INDIAN AFFAIRS.

1880.			
January 13	Stationery furnished	$4 77	
January 15	Stationery furnished	6 05	
February 4	Stationery furnished	64	
February 13	Stationery furnished	3 22	
February 27	Stationery furnished	1 43	
			$16 11

COMMITTEE ON ENROLLMENT.

1880.			
January 22	Stationery furnished	$1 86	
February 9	Stationery furnished	3 85	
March 1	Stationery furnished	1 83	
March 4	Stationery furnished	63	
March 8	Stationery furnished	3 11	
March 11	Stationery furnished	10 57	
April 3	Stationery furnished	66	
April 6	Stationery furnished	60	
April 12	Stationery furnished	1 38	
			$24 49

COMMITTEE ON FEDERAL RELATIONS.

1880.			
March 2	Stationery furnished		$5 77

COMMITTEE ON IRRIGATION, WATER RIGHTS, Etc.

1880.			
February 12	Stationery furnished	$9 98	
March 3	Stationery furnished	6 41	
			$16 39

COMMITTEE ON JUDICIARY.

1880.			
January 8	Stationery furnished	$2 55	
January 9	Stationery furnished	77	
January 10	Stationery furnished	11 50	
January 13	Stationery furnished	3 48	
January 16	Stationery furnished	4 40	
January 17	Stationery furnished	42	
January 19	Stationery furnished	2 40	
January 22	Stationery furnished	39	
January 23	Stationery furnished	26	
February 6	Stationery furnished	1 46	
February 5	Stationery furnished	1 10	
February 11	Stationery furnished	55	
March 5	Stationery furnished	5 70	
March 17	Stationery furnished	2 57	
March 27	Stationery furnished	45	
			$38 00

COMMITTEE ON LABOR AND CAPITAL.

1880.			
January......31	Stationery furnished		$16 03

COMMITTEES ON MILITARY AFFAIRS, AND MINES AND MINING.

1880.			
January......20	Stationery furnished	$16 54	
February..... 2	Stationery furnished	2 40	
February.....17	Stationery furnished	4 88	
March 3	Stationery furnished	3 31	
			$27 13

COMMITTEE ON PUBLIC BUILDINGS AND GROUNDS.

1880.			
January......27	Stationery furnished	$ 4 14	
February..... 4	Stationery furnished	5 06	
			$9 20

COMMITTEE ON PUBLIC EXPENDITURES AND ACCOUNTS.

1880.			
January......26	Stationery furnished	$ 2 01	
February..... 5	Stationery furnished	1 62	
February.....13	Stationery furnished	98	
April 3	Stationery furnished	1 11	
			$5 72

COMMITTEE ON PUBLIC LANDS.

1880.			
January......23	Stationery furnished	$ 5 07	
April 2	Stationery furnished	1 92	
			$6 99

COMMITTEE ON ROADS AND HIGHWAYS.

1880.			
February..... 3	Stationery furnished	$ 6 44	
March 10	Stationery furnished	2 44	
			$8 88

COMMITTEE ON STATE HOSPITAL.

1880.			
February.....12	Stationery furnished	$ 1 14	
February.....26	Stationery furnished	2 59	
March 2	Stationery furnished	3 57	
March 4	Stationery furnished	2 55	
March 16	Stationery furnished	5 02	
March 29	Stationery furnished	3 38	
			$18 25

COMMITTEE ON STATE PRISON.

1880.			
January ------16	Stationery furnished	$30 16	
January ------20	Stationery furnished	3 72	
February -----17	Stationery furnished	2 00	
March -------10	Stationery furnished	6 49	
			$42 37

COMMITTEE ON WAYS AND MEANS.

1880.			
January ------16	Stationery furnished	$ 5 29	
January ------20	Stationery furnished	29 22	
January ------31	Stationery furnished	70	
February ----- 8	Stationery furnished	4 24	
February -----28	Stationery furnished	13	
March ------- 4	Stationery furnished	1 75	
March -------11	Stationery furnished	40	
April -------- 5	Stationery furnished	1 60	
			$43 33

SAN FRANCISCO DELEGATION.

1880.			
January ------14	Stationery furnished	$11 13	
January ------15	Stationery furnished	4 56	
January ------16	Stationery furnished	43	
January ------22	Stationery furnished	26 77	
January ------29	Stationery furnished	30	
February ----- 5	Stationery furnished	5 57	
February ----- 5	Stationery furnished	55	
February -----10	Stationery furnished	4 23	
February -----11	Stationery furnished	58	
February -----18	Stationery furnished	1 30	
March ------- 1	Stationery furnished	3 73	
March ------- 8	Stationery furnished	90	
			$60 05

REPORT

OF THE

STATE BOARD OF EXAMINERS.

From January 1st, 1876, to December 31st, 1879.

REPORT OF THE STATE BOARD OF EXAMINERS.

BOARD OF EXAMINERS,
SACRAMENTO, January 1st, 1880.

To the Senate and Assembly of the State of California:

We have the honor to submit a report of the transactions of the State Board of Examiners, so far as the same is necessary for the information of the Legislature.

BONDS FOR SCHOOL FUND.

Section 680 of the Political Code requires that "whenever and as often as there is in the State treasury the sum of ten thousand dollars, as proceeds of the sale of State School Lands, the Board must invest the same in civil funded bonds of the State, or in bonds of the United States, at the lowest price at which they may be offered by the holders thereof."

Section 681 provides for "advertising in one newspaper in each of the Cities of San Francisco and Sacramento for sealed proposals for the purchase of said bonds."

By the Act of the Legislature, approved February 2d, 1872, the Board of Examiners is authorized to invest the money derived from the sale of State School Lands in the bonds of the several counties of this State.

In pursuance of the provisions of the Code, the Board advertised on August 3d, 1876, for the sale to the State of the bonds of the State and bonds of the United States.

On the day set for opening bids, there was but one bidder, who offered State and United States bonds on the following terms:

United States 5-20s, 6 per cent., issue 1865, at	$106 50
United States 5-20s, 6 per cent., issue 1867, at	107 50
California 7 per cent., payable on July 1st, 1883, at	107 50

It appearing that the United States bonds of 1865 would only yield 4.95 per cent., the bonds of 1867 4.94 per cent., and the California bonds only 5.51 per cent., the Board rejected the bid, and decided to advertise for county bonds, which was accordingly done.

Owing to the difficulty of obtaining United States and State securities, all of the investments of the State School Land Fund have been in county bonds, which bore a higher rate of interest or could be purchased at more advantageous rates than the former class of bonds.

The Board has, a number of times, advertised for bonds, and offers have been made to furnish bonds of certain counties of the State; but the Board has been compelled to reject the bids, owing to the fact that the Board deemed it advisable to invest only in bonds of

unexceptionable character. There remains now in the State School Land Fund the sum of $36,917 75, simply because such securities cannot be obtained by the method of public bidding by sealed proposals.

Table One shows the amount of bonds purchased, the county issuing them, the dates of the Acts of the Legislature authorizing their issue, the dates of their issue, where any date occurred, the price paid for them, their average duration, the rate of interest they bear, and the actual rate of interest per centum they yield to the School Fund.

As will be seen, the Board, between the 25th October, 1876, and 1st February, 1879, has invested in county bonds the sum of $297,320 13. Of this amount, the sum of $4,206 40 was the amount of interest that had accrued at the time of the purchase, and which was collected and paid into the State treasury and covered into the State School Fund at the time of the payment of the first coupon, thus leaving $293,113 73 permanently invested in bonds for the benefit of the State School Fund.

EXHAUSTED APPROPRIATIONS.

We have further to report that when certain claims which could not be paid because the appropriations for the payment of such claims had become exhausted, were presented to the Board they were allowed, when proper, and, after attaching the approval of the Board thereto, they were transmitted to the Controller, in whose office they are now on file, awaiting the action of the Legislature to make an appropriation of money for their payment.

The following shows the deficiency in the former appropriations to pay said claims:

FOR THE TWENTY-NINTH FISCAL YEAR.

For the contingent expenses of the Commissioner of Transportation	$102 70
For the support of the State Printing Office	112 00
For support of State Normal School	4 25
For payment of rewards offered for the arrest and conviction of highway robbers	300 00
For transportation of prisoners	3,051 46
For stationery, fuel, and lights	2,200 65

THIRTIETH FISCAL YEAR.

For payment of rewards offered by the Governor	$300 00
For arresting criminals without the limits of the State	252 70
For support of State Normal School	58 92
For contingent expenses of the Supreme Court	122 90
For traveling expenses of the State Board of Education	102 92
For support of the State Printing Office	31,144 26
For permanent improvement State Capitol grounds east of Capitol	152 88
For repairs of Capitol and furniture	857 00

THIRTY-FIRST FISCAL YEAR.

For deficiency in appropriation for repairs of State Capitol and furniture	$1,886 42

There is a deficiency in the appropriation for the improvement of the State Capitol grounds, which arose upon the following facts: The Legislature, at its twenty-second session, appropriated $10,000 for the improvement of the walks and avenues leading about the grounds of the State Capitol. The Capitol Commissioners contracted with the "California Artificial Stone Company" to lay down artificial stone upon the avenues and walks about the Capitol at a certain rate per square foot. As there was other labor necessary to be per-

formed upon the walks, such as the laying of sewers, the Board, at the time of settlement, reserved out of said appropriation the sum of $675 to pay for the same, leaving in the appropriation the sum of $9,325. When the work upon the walks was completed there was found due the contractor, the California Artificial Stone Company, the sum of $10,979 13. The claim of the company was audited and allowed by the Board of Examiners, but only $9,325 was paid the company, leaving due it the sum of sixteen hundred and fifty-four and thirteen-hundredths ($1,654 13) dollars. The claim is on file in the Controller's office, and the Board recommend its payment.

CLAIMS NOT PROVIDED FOR BY LAW.

In accordance with the provisions of Sections 664 to 667, Political Code, the following action was taken by the Board of Examiners on unsettled claims against the State of California not otherwise provided for.

1.

Robert Miller, for the use of horse during the months of March and April, 1876, in mowing the grass of the lawn around the State Capitol, $26.

The Gardener found the use of the horse necessary at the time and the service having been rendered, the Board approved the claim, and recommend its payment.

2.

L. L. Lewis, for two large globes for the lamps in the State Capitol grounds, $16.

The Board approves the claim, and recommends its payment.

3.

John Voorhies, for work of repairing Capitol, $230.

During the twenty-ninth fiscal year the Capitol needed repairing, and the Secretary of State, who is charged by law with the duty of keeping the Capitol in repair, had the repairing done by John Voorhies. There was no appropriation, however, for the payment of such claims, and Mr. Voorhies has not been paid. The Board allowed the claim for $230, and filed the voucher and approval with the Controller, and therefore recommends its payment.

4.

John F. Swift, claim, $6,000.

This is a claim for services rendered at the request of the Governor of the State, Newton Booth, in 1873, and during the absence of Hon. John Lord Love, then Attorney General.

Mr. Swift was employed by Governor Booth as an attorney on behalf of the State to prosecute certain suits in the Nineteenth Judicial District Court and in the Supreme Court, to oust John J. Marks and Jasper O'Farrell from the offices of State Harbor Commissioners.

All of the facts of the case are set out in the statement by Mr. Swift, which accompanies this report. The Board is satisfied that the services therein stated to have been rendered by him were faithfully

performed, and that he ought to receive some compensation therefor, but the Board declines to fix the amount which he should receive, and therefore transmits the papers to the Legislature for its action, with the recommendation that he should be paid such sum as the Legislature may determine that his services were reasonably worth.

5.

P. J. O'Connor, claim $3,000.

The Board of Trustees of the Napa State Asylum for the Insane employed the claimant, as an expert in architecture, to examine in detail the manner in which all claimants for moneys due upon contracts for the construction and furnishing materials used in the construction of the Asylum building for the insane at Napa had performed their contracts and agreements.

Mr. O'Connor entered upon the performance of his duties, and made, in due time, his report to the Trustees. For the services rendered he presented his claim for $10,000, that being the sum he alleged his services were worth. The Board of Trustees, deeming the charge exorbitant, declined to pay it, and fixed the value of his services at $2,500, which sum was accordingly paid to him.

Afterwards, on the 24th of May, 1877, Mr. O'Connor began an action in the District Court of the Twelfth Judicial District, San Francisco, against John Boggs and others, Trustees of the said Asylum, to recover the sum of $10,000. The defendants filed an answer, and such proceedings were had that the Court filed its findings on the 20th of February, 1879, and gave judgment against the plaintiff, in that "the plaintiff is not entitled to a judgment against the defendants, because they were acting as Trustees on behalf of the State, and such fact was known to the plaintiff."

It appears, however, from the findings of the Court, that a stipulation was entered into between the parties that, as the Court had heard all the facts, the Court should file its findings of fact. What purpose was subserved by this stipulation does not appear, for it is manifest it was not intended to have any binding force upon the Trustees, for they have since refused to pay the amount which the Court found was due Mr. O'Connor, to wit: $3,000, or any part thereof.

Accordingly Mr. O'Connor presented his claim before the Board of Examiners for its approval.

Upon the hearing of the case before the Board, there was a division of opinion upon the question of recommending the payment of the claim.

The Governor and the Attorney-General voted against such recommendation, and the Secretary of State voted in favor thereof.

The Secretary placed his approval of the claim upon the ground "that the Court, after hearing all the testimony in the case, had declared said claimant to be entitled to the amount claimed, and because the Board of Examiners, not having heard any testimony, and not being experts upon the question of the value of the services of an architect, could not properly say the value of claimant's services were less than the sum of $5,500, as found by the Court.

The Governor and the Attorney-General voted against approving the claim, and based their opposition on the ground that the Trustees had the best of opportunities to understand and value the services

of the claimant, and had undoubtedly paid to him all that his services were worth; and, moreover, that the Court having decided that plaintiff could not maintain his action against the defendants as Trustees, and having no jurisdiction over the facts of the case, that, therefore, the finding of the Court that the services of plaintiff were worth the sum stated by the Court, has no binding force upon the State.

The majority of the Board, therefore, recommend that the claim be not paid, and the minority recommend that it be paid.

6.

Claims against the State, arising out of contracts connected with the construction of the Napa State Asylum for the Insane, have been laid before the Board of Examiners, as follows:

Robert Ewing, for	$5,028 59
Adams & Co., for	646 42
James Hunter, for	697 44
Baker, Smith & Co., for	4,765 06
Wright & Sanders, for	9,600 43
E. L. Mayberry, for	5,835 97
Cox I. Colby, for	2,253 74
W. W. Montague, for	867 16
W. F. Wilson, for	1,671 11
H. H. Knapp, for	1,616 67
Cox & Warren, for	1,901 70
Frear Stone Co., for	4,699 87
Noble & Gallagher, for	2,775 73
George Mothersole, for	179 04
Electrical construction, for	728 87
	$43,267 80

Of this sum $30,872 88 is claimed as interest.

The facts are as follows:

The Legislature, at the session of 1871–72, appropriated $237,000 with which to commence the erection of an additional Insane Asylum. The Act making the appropriation provided that the Directors should not adopt any plan for a building of which one section could not be built and finished suitable for the reception of patients with the appropriation then made. The Directors adopted a plan of building which, according to the estimates of the architects, would cost $600,000 when completed.

Before the meeting of the Legislature of 1873–74, the appropriation made at the previous session had been exhausted, and, so far from one section being ready to receive the patients, no part of the building was above, or much above, the foundations. The Directors came to the Legislature and asked for a further appropriation with which to complete the building. They now asked for $600,000, which would run the total cost of the building up to $837,000, instead of $600,000, at which the original estimate of the architect had placed it.

The Legislature was not disposed to place implicit confidence in the estimate of what the building would cost, presented by the Board of Directors, nor in the disposition of the Board to keep the cost of the building within the limits of the appropriation that should be made. However, after the most positive assurances on the part of the Directors, supported by the authority of the architects, that the building could be completed for the sum asked for, the Legislature made an appropriation of $600,000 for its completion. To the appro-

priation was attached this proviso, to wit: "That the Board of Directors of said Napa State Asylum for the Insane are hereby directed and required to complete said Asylum for the sum hereby appropriated, and that said Board shall not let any contract which shall exceed that sum." (See Section 2 of the Act for the completion of Napa Asylum, page 565, Statutes, Session 1873–74.)

Section 4 of said Act is as follows:

Section 4. Any violation of or failure to comply with the provisions of section two of this Act by the Board of Directors of said Napa State Asylum for the Insane, or any of them, shall be a misdemeanor, and shall be punished as provided by law; *and all contracts made or debts contracted in violation of this or any other statute or statutes of this State defining their duties and powers, shall be void.*

Notwithstanding these stringent provisions of law attached to the appropriation, the Board of Directors acted in utter disregard of them. They did not complete the Asylum for the appropriation, as they had assured the Legislature they would; and did let contracts, which in the aggregate greatly exceeded the amount appropriated.

From the plain language of the statute, these two conclusions are inevitable:

First—The Directors were guilty of misdemeanor.

Second—The contracts let in excess of the appropriation were void.

As above stated, the Directors let contracts greatly in excess of the appropriation. The claimants above named all had contracts for doing work, or furnishing material for the Asylum; and the sum on which each claims interest is the amount which became due him on his contract, after the $600,000 appropriation was exhausted.

When the Legislature of 1875–76 met, the $600,000, appropriated at the previous session, had been exhausted; large sums were due which had accrued after the exhaustion of the said $600,000 appropriation; and the building was still far from being completed.

At that session the Legislature appropriated $494,000, "for the payment of the legal and equitable claims against the State incurred for work done and material furnished in the construction of the Napa State Asylum for the Insane, and for the completion of said structure," etc. (See Statutes 1875–76, page 804.)

This Act empowered the Board of Directors of the Asylum to pass on and audit the legal and equitable indebtedness of the State incurred in the erection of the Asylum; and directed the Controller to draw his warrants on the appropriation made to pay such indebtedness in favor of the Directors in such amounts as they should require.

As soon as a claimant's account was adjusted, and it was ascertained what the State owed him, he was given in payment a Controller's warrant. The Board, in adjusting the accounts of claimants, did not allow interest on the claim for the time since it had accrued, nor for the time that would elapse before the Controller's warrants would be paid.

We suppose the reason why they did not allow interest was, that the claims accrued on void contracts, that the contractor was bound to take notice of the law, and that he must have known that the Directors were exceeding their authority, and that his contract was, in consequence, void.

These claims accrued—at least, most of them accrued—at or before the 1st of January, 1876, and, although the appropriation to pay them

was made on the 1st of April, 1876, there was not money in the treasury to pay the warrants drawn on the appropriation till February, 1877.

The present claims are for interest on the amounts due the several parties, as adjusted by the Board of Directors, from the date when such amounts accrued till the Controller's warrants in which such amounts were paid were paid by the Treasurer, and for interest on such sums claimed as interest from February, 1877, to the present time.

Messrs. Wright & Sanders claim $9,600 43 as an unpaid balance of the percentage to which they were entitled, as the architects of the building.

On October 2d, 1876, they presented to the Trustees of the Asylum their account, aggregating $66,620. Of this sum, $1,500 was charged as traveling expenses to Napa, and $120 as expenses incurred in going to Sacramento during the session of the Legislature; the remaining $65,000 was the percentage they claimed for their services as architects. In their account the State had a credit of $40,000, leaving a balance due them of $26,620.

Upon the presentation of the account, the Board of Trustees appointed Mr. F. E. Johnston, their Chairman, to examine and report on it.

From this report we abstract the following:

The Board of Directors (the first Board appointed to superintend the construction of and to manage the Asylum was called the Board of Directors; this Board, pursuant to an Act of the Legislature, was superseded by another, appointed in March, 1876, denominated the Board of Trustees, etc.)—the Board of Directors, on the 12th of February, 1873, employed Messrs. Wright & Sanders as the architects for the construction of the Asylum building. They were to receive five per cent. on the contract price for the construction of the building.

The aggregate of the written contracts, as expressed on their face, is but little over $800,000, and if the contract with the architects was to be construed strictly and literally, they would be entitled to only about $40,000, the amount they have already been paid. This method, however, of arriving at the amount to which they are entitled for their services, would obviously be unjust, as it would not embrace a large amount of money expended for work done, under the contract at schedule price, which they superintended.

As, however, it is necessary to travel outside of the literal and express language of the contract with the architects to do them full justice, it will not be improper to take a general view of the situation at the time the contract was made.

It was believed by the Board of Directors, when the contract was made with Wright & Sanders, that a building could be constructed, according to their plans and specifications, for a sum not exceeding $600,000; in fact before the Board adopted their plans, they employed competent mechanics and builders to estimate on the cost of erecting a building according to such a plan. These estimates showed that the cost would be under $600,000.

It is further stated that Wright & Sanders gave a bond in the sum of $5,000 that a building constructed according to their plan should not cost over $600,000.

This plain statement of facts demonstrates that, at the time of the

employment of Wright & Sanders, they did not expect to receive over $30,000—5 per cent. on $600,000—for their services, and that the Directors did not expect to have to pay them more than that sum.

By reason, however, of changes made in the original plan, by order of the Board of Directors, the cost of the building was very much increased. And the architects claim that these changes imposed on them a very great amount of additional labor, alleging that their original drawings became worthless, and that they had to be to the labor and expense of making new ones.

This could have been the case, however, only to a limited extent. The building as constructed is exactly the same in form and size as the original design, but differently constructed. (See testimony of Mr. Wright, before the Senate and Assembly Committees, Vol. 5, Senate and Assembly Appendices, page 38, 21st session of the Legislature.) The greater part of the changes, therefore, which became necessary, in consequence of the change in the plan, were changes on the specifications alone. And as the specifications were not made till after the changes were ordered by the Board, the only extra compensation that could be justly claimed by the architects would be the difference in the cost of specifications for the building as originally designed, and the cost of specifications for it as erected.

Furthermore, the changes made increased the sum on which the architects are entitled to percentage. It would seem that this additional percentage should go far towards compensating them for their additional labor.

But to recur to the five per cent. theory set up by the architects:

The Legislature has appropriated in round numbers for the erection of the Asylum, and for purposes connected therewith, $1,330,000. Five per cent. of this sum is $65,500, only $1,500 more than Wright & Sanders claim as percentage. But of the whole amount appropriated, a large balance is yet unexpended, and large sums have been expended for purposes with which Wright & Sanders had no connection whatever: as the purchase of lands, the building of water-works, the salaries of officers, making repairs, material on hand, and for a great number of miscellaneous objects. It is difficult to see how the architects can be entitled to a percentage on the expenditures for such purposes.

After making as thorough an examination into the expenditures made by the Board of Directors and by the Board of Trustees under the supervision of the architects as practicable, and on which expenditures the architects are entitled to their stipulated percentage, it is believed that the total of such expenditures is not far from $1,000,000. Five per cent. of this sum is $50,000.

It is now submitted that this result accords, substantially, with the view heretofore presented by Wright & Sanders. On the organization of the Board of Trustees, March 16th, 1876, Mr. Wright was requested to make a statement of the amount that was owing at that date by the Asylum Directors, and also of the further amount that would be required to complete the building.

Prior thereto he had been required to furnish the same information to the Senate and Assembly Committees on Public Buildings and Grounds. He made the statement required; and, armed with this statement, the Board went before the Legislature and obtained an appropriation of $494,000 with which to pay off the existing indebtedness and complete the building.

In the statement submitted to the Board of Trustees on the 16th March, 1876, Wright & Sanders claimed as due them then only $16,109 07, and that their percentage on the work yet to be done to complete the building would be $7,056 04, making a total of $23,166. Prior to that time the Board of Directors had paid them for their services as architects, $30,000. At that date, therefore, they estimated the entire compensation to which they would be entitled for their services, up to the completion of the building, at $53,166. This sum is five per cent. of a little more than $1,000,000.

From the above statements, taken from the report of Mr. Johnston, made to the Board of Trustees in November, 1876, we get a general view of the grounds on which the Board refused to audit and pay the full amount claimed by Wright & Sanders for their services as architects.

But, at the request of the Board, Mr. Johnston made another report on the same subject, submitted to the Board of Trustees in March, 1877, in which he in detail points out the items of expenditures by the Board of Directors and the Board of Trustees, in which he thought the architects were not entitled to a percentage.

That report was as follows:

To the Honorable Board of Trustees Napa State Asylum for the Insane:

In pursuance of instructions given me at the last regular meeting of your honorable body, I submit the following:

According to the report submitted by Mr. R. Dudding, as expert, to the last Legislature, together with the monetary transactions of the old Board of Directors, I find that the whole amount appropriated by the Legislature and expended under the direction of said Board of Directors, is the sum of $841,047 70.

Whole amount appropriated		$841,047 70
Of this there was expended on Asylum grounds	$13,511 45	
Expended on water-works	16,506 16	
Expended on medical department	6,534 71	
Expended on medical department, interest, etc.	14,705 64	
		51,257 96
		$789,789 74

Thus far Mr. Wright and I agree that on the expenditures named he is not entitled to charge a commission. The report of Mr. Dudding further shows that the miscellaneous expenditures amounted to the sum of $61,998 50.

Of this amount, we agree that commission is to be charged on $7,700. We agree that on this amount commission should not be charged on $48,739 58.

We disagree as to charging commission on the following amounts: The sum of $4,187 50 paid to common laborers; the sum of $975 67 paid for constructing and fitting up rooms at Asylum for architect and clerk of works; the sum of $395 75 for rent of rooms in San Francisco and fitting up tables, etc., for use of contractors. In all, amounting to $5,558 92.

So that, up to the time of our advent into office, should my objections to the sum of $5,558 92 be sustained by your honorable body, the amount upon which Messrs. Wright & Sanders would be entitled to charge commissions would be:

Amount brought down	$789,789 74
Less $48,739 58 and $5,558 92	54,298 50
	$735,491 24
Should my objections be not sustained, they would be entitled to commission on $735,491 24 and $5,558 92	$741,050 16

Consequently, up to this point there is a difference of $277 94 commissions between us.

Since our advent into office we have audited, allowed, and paid, on account of bills contracted by the Board of Directors and contracts completed under our administration that had been entered into by said Board, the following named amounts:

STATEMENT OF BILLS AUDITED, ALLOWED, AND PAID.

To Whom Paid.	Amount.	For What.	Remarks.	Amount.
R. Bishop	$2,750 00	Granite contract	We owe Mr. Bishop about $545 00 still	
George J. Mothersole	4,355 66	State contract	From this I claim should be deducted: for taking off asphalt roof, $750; for 16 days repairing slate, $80; for piling do. and traveling expenses to San Francisco, $108 50	$938 50
W. H. Holliday	360 00	Labor	I contest this	360 00
Henry Colburn	129 25	Labor, Medical Dep't	I contest this	129 25
George Hamlin	15 00	Labor, Medical Dep't	I contest this	15 00
W. W. Frisbie	332 00	Brickmason, under Tucker	I contest this	332 00
L. Bruyere	359 45	Labor, Medical Dep't	I contest this	339 45
Thomas Hovey	35 00	Labor, Medical Dep't	I contest this	35 00
Richard Cuff	35 00	Labor, Medical Dep't	I contest this	35 00
D. K. Darbyshire	201 45	Corps Medical Dep't	I contest this	201 45
G. M. Francis	83 00	Printing, Medical Dep't	I contest this	83 00
F. W. Goddard	135 00	Night watch	I contest this	935 00
Matt. Gibson	333 50	Laborer and F	I contest this	333 50
E. R. Harrimon	126 50	Corps Medical Dep't	I contest this	126 50
N. R. Tucker	1,168 00	Clerk of works		
F. A. Miller	382 50	Brickmason under Tucker	I contest this	382 50
H. Goodmunsen	256 25	Common laborer	I contest this	256 25
J. H. Whalen	164 31	Corps Medical Dep't	I contest this	164 31
William Woolf	40 00	Labor, Medical Dep't	I contest this	40 00
John Turney	11 25	Labor, Medical Dep't	I contest this	11 25
E. Lambech	35 00	Labor, Medical Dep't	I contest this	35 00
John McMillan	30 00	Labor, Medical Dep't	I contest this	30 00
A. C. Bradford	275 69	Corps Medical Dep't	I contest this	275 69
A. Koutz	171 00	Labor, under Tucker	I contest this	171 00
Haas Brothers	13 25	Stationery	I contest this	13 25
Wells, Fargo & Company	83 10	Express on doc	I contest this	83 10
George Mothersole	55 50	Labor, under Tucker	I contest this	55 50
C. A. Bramlett	193 00	Labor	I contest this	193 00
John C. Molloy	123 00	Labor, under Tucker	I contest this	123 00
John C. Molloy	69 00	Labor, under Tucker	I contest this	69 00
John C. Molloy	81 00	Labor, under Tucker	I contest this	81 00
John Egan	35 00	Labor, Medical Dep't	I contest this	35 00

W. McEwen	35 00	Labor, Medical Dep't	I contest this	35 00
Thomas Cuff	35 00	Labor, Medical Dep't	I contest this	35 00
John Hadigan	15 00	Labor, Medical Dep't	I contest this	15 00
Patrick Hogan	12 75	Labor, Medical Dep't	I contest this	12 75
T. Mothersole	64 50	Labor, and Undertaker	I contest this	64 50
F. Manning	35 00	Labor, Medical Dep't	I contest this	35 00
George Hert	334 00	Labor, Medical Dep't	I contest this	334 00
Savage & Son	10 50	Road scraper	I contest this	10 50
A. Sampson	6 50	Drayage, Medical Dep't	I contest this	6 50
Allen & Parks	112 33	Hardware	I contest this	112 33
W. C. Watson	250 00	Treasurer	I contest this	250 00
A. Doble	342 00	Trustee	I contest this	342 00
J. H. Jewett	96 00	Trustee	I contest this	96 00
O. P. Ingraham	845 25	Elevator		
H. H. Knapp	11,824 51	Lumber	In this account I contest a number of items, as follows: 29,793 feet maple flooring, at $130 per M, $3,873 09: 61,226 feet spruce pine flooring, at $39 90 per M, $2,442 91; bill Oct. 8th, 1875, for $438 43; Jan. 31st, 1876, $232 67; Dec. 31st, 1875, $121 92; Dec. 1st, 1875, for $73 70; Dec. 31st, 1875, $238 95; March 4th, 1876, for $30 26; Feb. 29th, 1876, $45; Nov. 20th, 1875, $64 85. These bills were for lumber used in medical department. The lumber, maple and spruce flooring, is most all on hand and unused; what has been used, has been without Mr. Wright's knowledge or direction, and this aggregate of items, objected to, amounts to	7,793 38
F. A. Seaman	233 92	Blacksmithing	I contest of this allowance, the sum of $159 92, on the ground that it was for work for Medical Department	159 92
J. Bachelder	60 00	Extension joints		
F. A. Seaman	1,466 50	Window grates		
F. A. Seaman	1,004 23	Grates		
F. A. Seaman	358 75	Grates		
C. Nutting & Son	700 00	Grates		
Baker, Smith & Co.	35,640 61	Steam heating		
Cox & Colby	1,990 37	Brick	I contest of this account the sum of $116 99, on the ground that it belongs to Medical Department	116 99
Eckfeldt & Co.	795 40	Window blinds	This bill has not been paid because we have no offset, and I will contest to the amount of the offset when ascertained.	
Baker, Smith & Co.	300 00	For tools, etc.	I contest this	300 00
John R. Sim	3,360 90	Iron work		
James Hunter & Co.	1,098 00	Gal. iron work	We paid debt $1,220 for this sum.	
N. B. Perrine	790 07	Work and material		
Cox & Warren	17,012 81	Plastering	I contest for plastering damaged ceilings, $350; for cloth frames for windows, $364 15; for plastering temporary laundry, $17 50. Total	731 65
Noble & Gallagher	27,424 10	Painters and glaziers	I contest of this bill various items, consisting of repairs to windows, painting and oiling under Medical Department, amounting to	1,172 10

STATEMENT OF BILLS AUDITED, ALLOWED, AND PAID—Continued.

To Whom Paid.	Amount.	For What.	Remarks.	Amount.
W. F. Wilson & Co.	$12,200 28	Plumber	I contest of this bill various items for repairing water pipes, running pipe to stable, laundry, etc., amounting to	$309 22
James Hunter & Co.	8,302 60	Galvanized iron work	We paid debts $9,174, Cr. with this sum. I contest of this bill various items, repairing felt roof, 24 buckets, etc., amounting to	554 75
Adams & Co.	5,961 73	Locks		
Locke & Montague	7,163 44	Range and utensils		
E. L. Mayberry	82,298 57	Carpenter	I contest of this bill various items, for labor on barn, laundry, jobbing under Medical Superintendent. The principal items are, for 10 extra cottages $2,085, and extra on lumber $6,636, the whole aggregating	9,488 87
Robert Ewing	35,826 80	Brick mason	I contest of this bill, for office furniture, labor on dome houses, for workmen, extra on lumber, lime shed, sand, second-hand lumber, plastering cottages, etc., amounting to	2,683 98
F. A. Seaman	923 25	Grates		
Steamer expenses	42 50	Freight on furniture	I contest this	42 50
Geo. Howes & Co.	1,455 04	Freight on slate		
Steamer expenses	228 75	Freight on slate		
Bachelder M. & Co.	15 90	Castings for porticos	I contest this	15 90
Dunham, Carrigan & Co.	282 16	Gas retort	I contest this—Medical Department	282 16
Jas. Edgington	10 00	Carriage hire	I contest this—Medical Department	10 00
McBain & Co.	35 67	Hair		
W. F. Wilson	6,000 00	Plumber		
Thos. Cuff	40 00	Labor Medical Departm't	I contest this	40 00
L. R. Meyers & Co.	294 32	Slate		
Penn. Slate Co.	2,927 23	Slate	We paid debt in currency for this sum	
L. R. Meyers & Co.	29 50	Boxing slate		
A. Doble	11 25	Advance freight		
John Cochrane	10,141 00	Relief	I contest this	10,141 00
Cox & Colby	14,402 49	Brick	I contest of this bill for one boiler, $7; to use of carts for Medical Department, $116 99; for horses, barn, and fowls, $531; for 40,000 pressed brick, unused, at $30, $1,200	1,854 99
Eler Cowles	6,750 00	Clocks	I contest this because same has not been paid, and it looks as if it never would be	
Wright & Sanders	20,000 00	Architects	I contest this	20,000 00
N. P. Perrine	4,910 90	Labor and material	I contest of this bill the sum of $2,225 for temporary roofing, and $701 10 for asphaltum floor under kitchen	2,926 10
Frear Stone Co.	12,104 96	Frear stone	I contest of this bill the sum of $750 for sewering stone, and $1,250 for delivery to place of hoisting	2,000 00

Baker, Smith & Co.	1,592 50	Heating registers		
Jas. Hunter & Co.	6,462 80	Cala. iron		
A. M. Slocumb	30 00	Printing	I contest this	30 00
Wm. Jones	2,476 35	Tiling		
Mon. Marble Co.	880 00			
	$362,501 65			$73,834 59

So that, deducting the amount contested from the amount paid as above, we have the sum of $288,667 06 upon which Messrs. Wright & Sanders would be entitled to commissiou. If to this last named amount we add the amount paid by the Board of Directors, and upon which they are entitled to charge commissions, we have this result:

Paid by Directors	$735,491 24
Paid by Trustees	288,667 06
Total	$1,024,158 30

But, aside from the foregoing, Messrs. Wright & Sanders have done some work for us, other than the work done under us in completing some of the contracts entered into by the Board of Directors, and I state all our expenditures:

To Whom Paid.	Amount.	For What.	Remarks.	Amount.
W. H. Holliday	$645 74	Labor	I contest this	$645 74
John C. Molloy	148 50	Labor	I contest this	148 50
Matt. Gibson	130 50	Labor	I contest this	130 50
F. A. Miller	1,087 50	Labor	I contest this	1,087 50
George Hook	140 00	Night watch	I contest this	140 00
A. Reed	300 00	Night watch	I contest this	300 00
R. Jacks	22 50	Labor	I contest this	22 50
S. F. Chronicle	14 00	Advertising	I contest this	14 00
J. A. Jackson & Company	1,964 01	Lumber, lime, etc.	I contest of this bill the sum of	878 16
Gift & Purdon	49 25	Printing	I contest this	49 25
S. F. Bulletin	8 00	Printing	I contest this	8 00
G. M. Francis	6 00	Printing	I contest this	6 00
W. S. Moss & Company	44 25	Printing	I contest this	44 25
A. Sampson	206 75	Drayage	I contest this	206 75
H. H. Knapp	37 00	Lumber by railroad	I contest this	37 00
Z. W. Keyes	1,435 00	Clerk	I contest this	1,435 00
Mrs. Jacobson	128 07	Teaming	I contest this	128 07
California Pac. R. R. Co.	157 55	Freight, grates		

EXPENDITURES—Continued.

To Whom Paid.	Amount.	For What.	Remarks.	Amount.
Thomas Horey	$314 99	Labor	I contest this	$314 99
M. O'Donnell	92 37	Labor	I contest this	92 37
John Hadigan	16 25	Labor	I contest this	16 25
M. Leonard	477 02	Labor	I contest this	477 02
A. Y. Clark & Company	195 30	Labor		195 30
F. A. Seaman	3,301 95	Labor and materials	I contest this	3,301 95
Mr. Alcorn	12 00	Labor	I contest this	12 00
B. Robinson	1,754 10	Superintendent	I contest this	1,754 10
John Boggs	76 40	Trustee	I contest this	76 40
P. Van Bever	40 00	Trustee	I contest this	40 00
F. E. Johnston	150 00	Trustee, office rents, etc.	I contest this	150 00
George C. Perkins	53 40	Trustee	I contest this	53 40
A. C. Boggs	40 00	Trustee	I contest this	40 00
Steamer Emma	244 72	Freight	I contest of this	12 60
Thompson & Beard	26 26	Hardware, etc.	I contest of this	26 26
L. Bergen	16 00	Labor	I contest of this	16 00
Penryn Slate Company	541 25	Slate		
California Pac. R. R. Co.	2,501 00	Freight and charges		
N. P. Cole & Company	200 00	Furniture	I contest this	200 00
John Penny	346 00	Labor	I contest this	346 00
E. L. Mayberry	114 05	Labor and materials	I contest this	114 05
B. L. Robinson	609 00	Labor, carpentering	I contest this	609 00
J. C. White	259 25	Freight	I contest this	259 25
Batchelder Manufac. Co.	252 22	Mill work	I contest this	252 22
N. H. Wolfe	39 50	Asphaltum	I contest this	39 50
J. Gilchrist	570 88	Mill work	I contest this	570 88
Henry & Coine	9 50	Drayage	I contest this	9 50
E. Biggs	242 78	Labor and hire team	I contest this	242 78
Low & Chorlery	1,178 95	Washing machine	I contest this	1,178 95
Joseph Edgington	15 00	Carriage hire	I contest this	15 00
Goodman & Company	2,813 00	Interest and discount	I contest this	2,813 00
Robert Crouch	40 00	Abstract	I contest this	40 00
Prescott, Scott & Co.	2,742 00	Engine, etc.	I contest this	2,742 00
Huntington, Hopkins & Company	695 11	Hardware	I contest of this bill the sum of	219 63
Pacific Rolling Mills	1,061 49	Rail iron		
G. G. Lymon	80 00	Survey	I contest this	80 00

Alexander Coutz	373 50	Labor	I contest this	373 50
T. McGuire	5 00	Labor	I contest chis	5 00
Joseph Wickham	86 00	Labor	I contest this	86 00
L. Maskins	217 50	Labor	I contest this	217 50
A. J. Smith	135 00	Labor	I contest this	135 00
W. W. Fisher	60 00	Labor	I contest this	60 00
J. B. C. Gildesleeve	209 00	Labor	I contest this	209 00
Stone & Baker	1,433 27	Hardware	I contest this	1,433 27
R. Ewing	9 00	Iron pipe	I contest this	9 00
Gas Company	29 00	Coal tar	I contest this	29 00
W. F. Wilson	615 44	Plumbing, etc.	I contest this	615 44
D. L. Haas	6 15	Stationery	I contest this	6 15
T. Connell	25 87	Labor	I contest this	25 87
Thomas Smith	25 87	Labor		25 87
E. G. McClure	125 00			125 00
M. Heverin	1,950 00	Mantels		
B. Robinson & Son	22 50	Tools	I contest this	22 50
N. R. Tucker	4,091 70	Walls	I contest this	841 70
D. Rose	181 00	Moving houses	I contest this	181 00
E. McGrath	810 00	Mantels	I contest this	810 00
Adams & Company	57 20	Locks	I contest this	57 20
A. B. Robinson	140 00	Labor	I contest this	140 00
B. Bailey	126 00	Labor	I contest this	126 00
A. Bailey	352 00	Labor	I contest this	352 00
M. Gibson	229 00	Labor	I contest this	229 00
John J. Nunan	113 00	Labor	I contest this	113 00
P. J. O'Connor	2,500 00	Expert	I contest this	2,500 00
W. T. Garratt	62 00	Gauges for engine	I contest this	62 00
Wright & Fowler	4 25	Blacksmith	I contest this	4 25
E. Kimball	247 69	Tinsmith	I contest this	247 69
N. R. Tucker	136 00	Sand	I contest this	136 00
George J. Mothersole	177 78	Repair of slate, etc.	I contest this	177 78
W. F. Henning	314 85	Paints, oils, etc.	I contest this	314 85
Savage & Son	17 75	Carting	I contest this	17 75
Moynihan & Aitken	65 00	Asphaltum kettle	I contest this	65 00
Morning Call	70 00	Advertising	I contest this	70 00
Thomas Morris	12 50	Labor	I contest this	12 50
John Cox	10 00	Labor	I contest this	10 00
A. J. Gallagher	196 00	Painting	I contest this	196 00
Michael Daley	165 50	Laborer	I contest this	165 50
Philip Farley	125 50	Laborer	I contest this	125 00
Ingraham Bros.	5,375 00	Elevators		
J. B. Owens	119 65	Laborer	I contest this	119 65

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EXPENDITURES—Continued.

To Whom Paid.	Amount.	For What.	Remarks.	Amount.
T. P. Ewing	$100 50	Laborer	I contest this	$100 50
E. H. Brisco	10 00	Tools	I contest this	10 00
Miller & Sylvester	27 05	Paper, etc.	I contest this	27 05
Moody & Aldrich	43 50	Plow, etc.	I contest this	43 50
Baker, Smith & Co.	57 90	Pipe, etc.	I contest this	57 90
Baker, Smith & Co.	3,344 75	Covering pipe and grates	I contest three thousand of this	3,000 00
William Schnode	200 00	Surveying instruments	I contest this	200 00
Daniel McCarty	177 00	Teams, etc.	I contest this	177 00
L. Brown	372 00	Teams, etc.	I contest this	372 00
M. McCann	126 00	Labor	I contest this	126 00
M. McCann	8 75	Labor	I contest this	8 75
M. Donahue	26 00	Labor	I contest this	26 00
W. S. Moore	33 00	Labor	I contest this	33 00
A. Truax	3 00	Labor	I contest this	3 00
Alexander Scott	28 00	Labor	I contest this	28 00
F. Folk	115 00	Labor	I contest this	115 00
F. Folk	47 50	Labor	I contest this	47 50
N. P. Perrine	1,314 00	Corridors	I contest this	1,314 00
W. Commory	60 00	Labor, carpentering	I contest this	60 00
T. McFerrin	172 00	Labor, carpentering	I contest this	172 00
J. Metcalf	40 00	Labor	I contest this	40 00
Thomas Grady	8 00	Labor	I contest this	8 00
H. S. Colburn	84 00	Labor and carpentering	I contest this	84 00
John True	40 00	Labor	I contest this	40 00
John Rymer	2 75	Labor	I contest this	2 75
P. McCoy	3 00	Labor	I contest this	3 00
L. Kreuzer	3 00	Labor	I contest this	3 00
	$55,318 13			$37,954 54

Assuming that my objections to the foregoing amounts contracted and paid by your honorable body are well taken, then there would be $55,318 13, minus $37,954 54—$17,363 59—upon which Messrs. Wright & Sanders would be entitled to charge commission. This added to the previous amount would make the sum of $1,041,521 82, and five per cent. of that amount would be $52,076.05, assuming that they are entitled to five per cent. If none of my objections are well taken, then the amount upon which they would be entitled to charge commissions, as per statements above, is the sum of $1,153,311 02, and five per cent. on that sum is $57,665 55. But I adhere to my former proposition, viz: that for all work done after your advent into office there was a statement on your part that five per cent. was too high, and that Messrs. Wright & Sanders were not in your employ at that rate of compensation.

Aside from all this, I find that we have paid at least $100,000 for extra work—that is work not shown upon the plans or called for in the specifications—and it does seem to me that they are not entitled to the same compensation for such work as for that done under contract.

In conclusion, I request that if there be any more such labor as is involved in the making of this report, that your honorable body will please designate some other person.

Respectfully submitted.

March 8th, 1877. F. E. JOHNSTON.

8.

The Frear Stone Company have a claim of $3,600 for statuary made and placed in position at the Asylum.

The contract was made with the Frear Stone Company for the statuary by the old Board of Directors, and it was claimed by the Board of Trustees that it was void, for the reason that it was a contract in excess of the $600,000 appropriated for the completion of the Asylum.

Holding the contract to be void, the Board of Trustees, on their accession to office, gave notice to the Frear Stone Company that they would not receive nor pay for the statuary.

The Frear Stone Company, however, proceeded with the work—which they claim they had begun and had well under way before receiving the notice from the Trustees that it would not be received—and in due time completed and placed it in position at the Asylum.

Against the statement of the Frear Stone Company, as to the amount of the labor done and the expense incurred on the statuary at the time the notice was given that it would not be received, the Board of Trustees say that but little, if any, work had been done or expense incurred on it.

If the contract for the statuary, as originally made by the Board of Directors, was illegal and void, there can be no question that the Board of Trustees could refuse to validate it.

In respect to the claims growing out of the contracts for the construction of the Napa State Asylum for the Insane, the Board of Examiners have no recommendations to make as to the propriety or justice of their payment by the Legislature, but prefer merely to report the plain facts of the case, which they believe they have done with strict impartiality.

WILLIAM IRWIN, Governor,
THOMAS BECK, Secretary of State,
JO HAMILTON, Attorney General,
State Board of Examiners.

TABLE ONE,

Relating to Bonds Purchased by the Board of Examiners for the State School Fund.

Date of Purchase.	County.	Date of Act Authorizing Issue.	Date of Issue.	Average Years to Run	Interest on Face	Actual Interest	Amount Paid, including accrued Interest per $100	Accrued Interest	Net Cost	Face of Bonds	Cost	
October 25, 1876	Humboldt	February 12, 1876	Sept. 14, 1876	19	9	8	$107 75	$00 75	$107 00	$15,000 00	$16,162 50	
October 25, 1876	Santa Barbara	March 13, 1876		10	10	8.176	113 00	2 95	110 05	20,000 00	22,600 00	
October 25, 1876	San Luis Obispo	March 18, 1874	May 10, 1876	8	10	8 080	112 00	2 95	109 05	10,000 00	11,200 00	
October 25, 1876	San Luis Obispo	April 3, 1876	August 14, 1876	12½	8	8.000	101 38	1 38	100 00	10,000 00	10,138 00	
October 25, 1876	Tehama	February 25, 1876	April 4, 1876	18½	8	8.000	103 00	3 02	99 98	11,500 00	11,845 00	
October 25, 1876	Tulare	February 7, 1876	May 30, 1876	16	10	8,180	115 80	3 80	112 00	20,000 00	23,160 00	
October 25, 1876	Lake	March 11, 1876	May 6, 1876	11	7	8.086	97 00	3 11	93 89	11,400 00	11,058 00	
October 25, 1876	Mendocino	March 20, 1876	Sept. 12, 1876	15	8	8.000	100 75	75	100 00	10,000 00	10.075 00	
October 25, 1876	San Joaquin	March 11, 1876	July 1, 1876	7	10	8.201	111 00	2 95	108 05	5,000 00	5,550 00	$121,788 50
March 23, 1877	Humboldt	March 28, 1876	February 13, 1877	16	9	7.360	113 42	92	112 50	10,000 00	$11,342 00	11,342 00
August 1, 1877	Sacramento	April 24, 1858	January 1, 1859	16	6	6.645	95 00	3 38	91 62	1,200 00	$1,140 00	
August 1, 1877	Sacramento	April 24, 1858	January 1, 1859	16	6	6.000	103 30	3 30	100 00	14,800 00	15,288 40	
August 1, 1877	Santa Clara	March 27, 1876	May 18, 1877		7	6.000	108 00	44	107 56	5,000 00	5,400 00	
August 1, 1877	San Luis Obispo	April 3, 1876	March 22, 1877	20	8	6.304	115 00	18	114 82	30,000 00	34,446 75	56,275 15
October 2, 1877	Sacramento	April 24, 1858	January 1, 1859	14	6	6.132	99 00		99 00	10,400 00	$10,296 00	10,296 00
Sept. 11, 1878	Solano	March 2, 1878	July 1, 1878	6½	7	6.140	105 34½	1 34½	104 00	10,000 00	$10,534 17	
Sept. 11, 1878	San Luis Obispo	March 31, 1878	July 1, 1878	10	8	6.070	113 53½	1 53½	112 00	10,000 00	11,353 33	
Sept. 11, 1878	Stanislaus	March 14, 1878	June 24, 1878	7½	8	6.100	111 12	1 37	109 75	10,000 00	11,112 77	
Sept. 11, 1878	Napa	March 27, 1878		12½	7	6 ×	107 17½	17½	107 00	20,000 00	21,435 00	54,435 27
Nov. 7, 1878	Napa	March 27, 1878		12½	7	6 ×	107 05×	05×	107 00	19,500 00	$20,876 37	20,876 37
February 1, 1879	Napa	March 27, 1878		12	7	6 ×	107 57	57	107 00	20,500 00	$22,052 64	22,052 64

	$297,065 93
When the bonds were purchased, October 25th, 1876, the price was based upon delivery on October 16th, but as delay occurred in examining them, and they were not paid for until the 25th, nine days accrued interest was added, amounting to	254 20
Total amount invested in bonds	$297,320 13

REPORT OF COMMISSION

TO

EXAMINE INTO AND REPORT

ON THE

CONDITION OF CERTAIN FUNDS, ETC.,

IN

RELATION TO THE STATE UNIVERSITY.

SACRAMENTO:
STATE OFFICE : : : F. P. THOMPSON, SUPT. STATE PRINTING.
1879.

REPORT.

Sacramento, November 4th, 1879.

To the Honorable the Senate and Assembly of the State of California:

Gentlemen: The Legislature of 1877–8 enacted as follows:

Section 1. The Controller of State, the Surveyor-General, the Attorney-General, and State Treasurer are hereby appointed a Commission for the purpose of examining and reporting to the next Legislature the condition and disposition of the Congressional Seminary Land Grant of seventy-two sections and interest arising therefrom, the Congressional Public Building Land Grant of ten sections and interest arising therefrom; the transfer of certain bonds in accordance with an Act entitled "An Act requiring the Controller of State to transfer certain funds," as provided for in Section 1 of said Act, approved March 26th, 1868; the condition and amounts of money received from the sale of tide lands and invested under an Act entitled "An Act for the endowment of the University of California," approved April 2d, 1870; the amount of money paid to the Regents of the University of California in conformity with an Act entitled "An Act to provide for the support of the University of California," and the several dates of payment thereof, approved April 1st, 1872.

Sec. 2. As soon as practicable after the passage of this Act the persons named in Section 1 of this Act shall proceed to examine the books of the State Controller, the Surveyor-General, the State Treasurer, and the various Acts concerning the State University, for the purpose of determining the condition and disposition of the various funds mentioned in Section 1 of this Act.

Sec. 3. It shall be the duty of the said Commission to report the results of their examinations, as provided in Sections 1 and 2 of this Act, to the next Legislature of this State.

In obedience to the above recited Act we have the honor to report as follows:

The books of the Register of the State Land Office show that of the seventy-two sections (46,080 acres) of Seminary Land above referred to, 46,042.13 acres have been selected by the State, and 47,771.35 acres have been sold (1,760 acres was sold and afterwards forfeited and sold again); from which it appears that said grant is about exhausted. According to the Register's books there has been paid to the several County Treasurers of this State, on account of the sale of the said seventy-two sections, the sum of $89,736 76. The Controller's books show that of the said sum of $89,736 76 there has been paid into the State treasury, from date of first sale to July 1st, 1879, the sum of $67,012 47, of which $44,632 24 is principal and $22,380 23 is interest. The disposition of the said sum of $44,632 24 principal was as follows: $3,094 87 was paid into the State School Land Fund; $9,665 05 was paid into the Seminary Fund, and $31,872 32 was paid into the University Fund. The said sum of $22,380 23 interest, as above, was disposed of as follows: $3,281 50 was paid into the School Fund;

$10,364 25 was paid into the Seminary Fund; $8,107 28 was paid into the University Fund, and $627 20 was paid into the University Endowment Fund. Thus it appears that while the Register's books show sales of said Seminary Lands to the amount of $89,736 47, the Controller's books show but $67,012 47 as the amount actually paid into the State treasury as the result of said sales, leaving a balance *apparently* unaccounted for of $22,724 29.

Of Public Building Lands mentioned in the foregoing Act (creating Commission), the books of the Register of State Lands show that of the ten sections granted, the State has selected 6,195.99 acres, and has sold 7,055.82 acres (974.24 acres having been sold and forfeited and resold, leaving 6,081.58 acres as the amount actually sold by the State), and that there are 320 acres thereof yet unsold; that there was realized from said sales the sum of $10,186 14, making the total amount received by County Treasurers for sales of both kinds of land (as per Register's books) to be $99,922 90. The Controller's books show that of the said sum of $10,186 14 there has been paid into the State treasury for principal $5,451 91; for interest, $2,104 99; total, $7,556 90.

The said principal sum of $5,451 91 was disposed of as follows: $306 25 was paid into State School Land Fund; $374 05 was paid into the Public Building Fund, and $4,771 61 was paid into the University Fund. The said interest of $2,104 99 was disposed of as follows: $171 08 was paid into School Fund; $834 86 was paid into the Public Building Fund, and $1,099 05 was paid into the University Fund. From which it follows that of the said sum of $10,186 14, result of sales as shown by Register's books, there is apparently unaccounted for by Controller's books the sum of $2,629 24. This, added to the amount of sales of seventy-two sections apparently unaccounted for, to wit, $22,724 29, makes a total (from sales of both kinds of land) of $25,353 53 *that does not seem to have found its way into the State treasury.*

Of the above amounts produced by the sales of Seminary and Public Building Land, and paid into State treasury, the Controller's books show that the School Fund received the sum of $3,452 58, and the State School Land Fund received the sum of $3,401 12.

In reference to the balance aforesaid of $25,353 53, apparently unaccounted for by Controller's books, it is impossible to speak with certainty, as the Auditor's reports, upon which County Treasurers made their settlements with the State from the first sales up to the latter part of the year 1863, did not give the necessary information to enable the Controller to tell, in many instances, whether the land money reported was for School Land, Seminary Land, or Public Building Lands. In a number of instances where the Register's books show that Seminary and Building Land money should have been reported from the different counties, the Auditor's reports from said counties for said time show no money other than School Land money.

From all the facts we can gather in the matter, we are of the opinion that most of the said sum of $25,353 53, given above as apparently unaccounted for by the Controller's books, was paid into the State treasury to the credit of the School Fund. There was a portion of the said sum lost to the State on account of defalcations of County Treasurers—how much your committee cannot ascertain. Considering that the whole of said sum was truly accounted for by County

Treasurers, and that the State was to be held responsible for the same to the University, the account would stand as follows, viz.:

Whole amount of Seminary Land and Building Land money received by County Treasurers from date of first sale of said lands to July 1st, 1879, and not accounted for by Controller's books	$25,353 53
Less Treasurers' commissions on total receipts from sales of said lands, to wit, 3 per cent. on $99,922 90	2,997 68
Leaving the net sum due University to be	$22,355 85
To this must be added the sums of $3,452 58 and $3,401 12 of Seminary and Public Building Land money, shown by Controller's books to have been paid into the School Land Fund and School Fund, a total of	6,853 70
Making a grand total of	$29,209 55

Which last named sum represents the greatest amount that could have been diverted from the proceeds of Seminary and Building Lands to the School and School Land Funds, from date of first sale to July 1st, 1879, and we find that most of said sum of $29,209 55 was paid into, or should have been paid into, the State treasury prior to March 26th, 1868, the date of the said transfer Act, to which our attention is directed.

The Controller's books show, that from the proceeds of Seminary and Public Building Lands, there was paid into the State treasury, up to July 1st, 1879, the sum of $74,569 37; that $6,853 70 thereof was paid into the State School Land and School Funds, as aforesaid, and used for school purposes, and the remainder, to wit, $67,715 67 was drawn by the Regents of the University for the support and endowment of said institution.

TRANSFER OF BONDS AND MONEY.

On March 26th, 1868 (see Statutes 1867-8, page 357), the Controller was ordered to transfer to the University Fund State seven per cent. bonds to the amount of $35,100, and also to transfer from the School Fund to the University Fund the sum of $44,064 in coin. In obedience to said Act the Controller transferred from said School Fund to said University Fund the said sum of $44,064, in coin, and transferred to said University Fund State seven per cent. bonds to the amount of $35,000, which said bonds had been purchased for and were held in trust for the common schools of the State. We have endeavored to ascertain the reason for this order to transfer from the common schools to the University the large sum of $79,064. Upon consulting the Journals of the Senate and Assembly for the year 1868, we found that the said bill for said transfer was passed through both Houses without reference to any committee whatever—it passed the Senate on March 24th, 1868, and in the Sacramento Union of March 25th, 1868, we find the explanation of the bill by its author, Mr. Hager, and by Lieutenant-Governor Holden, in words as follows:

"By Mr. Hager—An Act to require Controller to transfer," etc.

The author stated that the design was to create a fund to put the machinery of the State University into motion. The proposition was based upon the fact that the money in question belonged properly to the University Fund. The amount was some $35,100. He suggested that the Lieutenant-Governor have leave to explain the matter more fully, as he was a member of the University Board.

The Lieutenant-Governor proceeded to state that the Seminary Fund was derived from the grant of seventy-two sections of land donated by Congress to the State for a seminary of learning. There were in it 46,800 acres, which were sold under an Act providing therefor, and also

for the sale of the 500,000 acres, at $1 25 an acre. A portion of the proceeds had been used by the School Fund since 1858–9, and there had grown up an interest, due the Seminary Fund from the School Fund, amounting to $44,064. The bill provided for the return of these amounts, and also for the disposition of a balance derived from the Public Building Fund.

The bill was passed and ordered transmitted to the Assembly.

The foregoing explanation contains all the light thrown upon the subject of this transfer that our researches have revealed. It does not appear that any one was acting for the State, or on behalf of the School Fund, or that a proper investigation of the indebtedness of the School or State School Land Funds to the University Fund was had at the time either by committee or otherwise. As we have shown in the preceding pages of this report that not more than $29,209 55 *could have been diverted from the Seminary and Public Building Land Funds into the School Fund*, from the date of first sale to July, 1879, we are forced to the conclusion that more than $50,000 of the transfer of $79,064, made under the Act of 1868, was in excess of the amount due from said School and State School Land Funds to the University Fund.

ACT OF EIGHTEEN HUNDRED AND SEVENTY.

Under "An Act for the endowment of the University of California," approved April 2d, 1870, we find that the Controller, with money received from the sale of salt marsh and tide lands, purchased, for the University, State bonds of the par value of $750,000, and that said bonds yield an annual interest of $46,350. We are of the opinion that he should have invested in bonds, from the proceeds of the sale of said tide lands, a sufficient sum to have yielded an annual interest of $50,000; but whether the University Fund or the School Fund was injured by his failure to do so depends upon the construction to be placed upon the said Act of April 2d, 1870, to which the attention of your honorable body is directed.

ACT OF MARCH SECOND, EIGHTEEN HUNDRED AND SEVENTY-TWO.

In conformity with the provisions of this Act the Controller, upon the statements of receipts and expenditures made by the Regents of the University, drew warrants in favor of said University for two years, aggregating the sum of $126,437 41, in detail as follows:

LIST OF WARRANTS DRAWN FOR DEFICIENCIES.

	Expenditures.	Receipts.	Deficiency.	Date and Number of Warrant, and Fund.
Requisition for March, 1872	$3,630 00	$1,364 68	$2,265 32	May 14, 1872—9,850, University Fund.
Requisition for April, 1872	5,710 55	334 00	5,376 55	June 5, 1872—10,071, University Fund.
Requisition for May, 1872	5,995 97	224 02	5,771 95	July 20, 1872—564, University Fund.
Requisition for June, 1872	5,991 66	846 94	5,144 72	September 3, 1872—1,654, University Fund.
Requisition for July, 1872	5,956 40	2,120 98	3,835 42	
Requisition for August, 1872	5,992 30	338 65	5,653 65	October 15, 1872—2,761, University Fund.
Requisition for September, 1872	5,973 67	30 50	5,943 17	November 9, 1872—3,329, University Fund.
Requisition for October, 1872	6,001 06	446 62	5,553 38	December 18, 1872—3,711, General Fund.
Requisition for November, 1872	5,998 92	189 13	5,809 79	
Requisition for December, 1872	5,996 40	1,084 75	4,911 65	January 21, 1873—4,108, General Fund.
Requisition for January, 1873	6,035 94		6,000 00	February 5, 1873—4,326, General Fund.
Requisition for February, 1873	6,087 47		6,000 00	March 6, 1873—4,561, General Fund.
Requisition for March, 1873	7,440 56		6,000 00	April 22, 1873—4,911, General Fund.
Requisition for April, 1873	6,896 94		6,000 00	June 7, 1873—5,397, General Fund.
Requisition for June, 1873	7,851 25	248 73	5,751 27	July 23, 1873—132, General Fund.
Requisition for July, 1873	5,995 76	277 07	5,718 69	August 5, 1873—622, University Fund.
Requisition for September, 1873*	5,999 96	1,755 62	4,244 34	October 8, 1873—1,268, General Fund.
Requisition for August, 1873*	5,998 72	150 20	5,848 52	October 8, 1873—1,271, University Fund.
Requisition for October, 1873	5,998 25	1,506 97	4,491 28	November 19, 1873—1,697, General Fund.
Requisition for November, 1873	6,001 26	286 71	5,713 29	December 5, 1873—2,009, General Fund.
Requisition for balance in University and University Endowment Funds			16,380 80	January 10, 1874—2,978, University Fund.
Requisition for February, 1874*	5,946 15	2,006 38	3,993 62	April 8, 1874—6,576, General Fund.
F. Baehr, expenses collecting July interest on U. S. Bonds			10 00	August 20, 1872—1,507, University Fund.
F. Baehr, expenses collecting January interest on U. S. Bonds			10 00	January 10, 1873—4,031, University Fund.
F. Baehr, expenses collecting July interest on U. S. Bonds			10 00	July 8, 1873—24, University Fund.
Totals	$127,499 19	$13,211 95	$126,437 41	

* The expenditures shown by statement attached to voucher 6,576 are actually $5,946 15; receipts, $2,006 38. The warrant should have been issued for $3,939 77 instead of $3,993 62, which was an overpayment of $53 85, because the receipts were deducted from the limit of expenditures allowed by law—$6,000—instead of from $5,946 15, the actual expenditure.

From the above it appears that under said Act the sum of $126,-437 41 was paid to the University; that $64,468 62 thereof was paid out of the General Fund, and $61,968 79 was paid out of the University Fund; but we find upon investigation that in drawing upon the University Fund for said $61,968 79, the Controller erroneously overdrew said University Fund to the extent of $7,312 18, and had to transfer that amount from the General Fund to the University Fund to meet said overdraft. So that, in reality, of the $126,437 41 paid to University, as aforesaid, the General Fund furnished $71,780 80, and the University Fund, $54,656 61.

Included in the $54,656 61 of University money used by the Controller to pay deficiencies, as in the table above set forth, there was the sum of $9,870 60, which was in the University Fund several months prior to the passage of the Act of 1872. Of this sum of $9,870 60, $2,873 18 was the principal obtained from sale of Seminary Land; $959 92 was interest from same source, and $6,037 50 was from interest on bonds held in trust for University. Whether any of this $9,870 60 was properly used by the Controller to pay deficiencies under the said Act is, to say the least, doubtful. But we are clearly of the opinion that the sum of $2,873 18 principal, for Seminary Land sold, should not have been used for any purpose but that of a permanent endowment of the University. (See Article IX, Section IV, old Constitution.) There was also principal of Seminary Land and Public Building Land amounting to $4,470 49 received into the University Fund after April 1st, 1872, which was used by the Controller to pay said deficiencies, and, as we think, used wrongfully. According to the construction placed upon the said Act of 1872, by the authorities of the University, the Controller used more of the interest on bouds held in trust for the University for payment of deficiencies than was allowable. Whether he did so or not depends upon the proper construction of the said Act of March 2d, 1872, to which reference is respectfuliy made.

W. B. C. BROWN, Controller,
JOSÉ G. ESTUDILLO, Treasurer,
JO HAMILTON, Attorney-General,
WILLIAM MINIS, Surveyor-General.

REPORT

OF THE

Board of State Prison Directors

IN RELATION TO THE

FOLSOM BRANCH STATE PRISON.

1[k]

REPORT.

An Act of the Legislature, approved April 1st, 1878, authorized and directed the Board of State Prison Directors to commence the completion of the Branch State Prison, near the Town of Folsom, in Sacramento County, on or before the 1st day of July, 1878; and to continue such work without unnecessary delay until the appropriation for the purpose should be exhausted.

For such work the Act appropriated $120,000; and also re-appropriated $85,494 73, then in the Branch State Prison Fund, thus making the total sum appropriated for the purpose, $205,494 73.

It was provided, however, that all the provisions of the Act looking to the completion of the Branch Prison should be null and void, and the sums appropriated for such purpose covered back into the General Fund of the Treasury, unless the Board of Directors should be able, on or before the 30th day of June, 1878, to make contracts with responsible parties for the hire of the labor of not less than 350 convicts for five years, at not less than fifty cents a day for the labor of each convict.

Pursuant to such provision of the Act requiring that a contract for the hiring of the labor of prisoners be made before proceeding with the work of completing the Branch Prison, the Prison Directors, on the 29th day of June, 1878, entered into a contract with H. G. Livermore, by which he bound himself, with good and sufficient sureties, in such penal sum as the Act prescribed, to hire the labor of 350 prisoners for a period of five years, at fifty cents a day for the labor of each prisoner.

The Board advertised in the public journals of San Francisco and Sacramento for bids for the hire of the labor of convicts, but the bid of Mr. Livermore was the only one received.

The duty of the Board to proceed with the completion of the Branch Prison having become absolute on the making of the contract with Mr. Livermore, they forthwith entered on the discharge of such duty.

The Act imposing this duty provided two modes in which the work might be done, and empowered the Board of Directors to select the one which in their judgment would best subserve the interests of the State. The one mode contemplated the employment of convicts in the construction of the prison building; the other, that a certain plan and specifications, prepared and submitted to the legislative committees on State Prison affairs by A. A. Bennett, should be adopted, and the building be erected according to such plans and specifications by contract.*

After maturely considering the whole subject, the Board adopted

* The plan submitted by Mr. Bennett was substantially the same as that originally adopted for the Folsom Branch State Prison in 1874, and according to which the erection of the prison was then commenced. Certain modifications or changes in the mode of construction, however, were made. No material variation from the plan originally adopted could be made which would not involve the loss of the work already done.

the plan and specifications of Mr. Bennett, and also concluded that it would be for the interests of the State to have the work done by contract.

Upon consultation with the Attorney-General, they came to the further conclusion that, in letting such contract and supervising its execution, they would be subject to the provisions of an Act entitled "An Act to regulate contracts on behalf of the State, in relation to erections and buildings," approved March 23d, 1876 (see Statutes 1875-76, page 427)—in fact, to all the provisions of said Act, except to those which prescribe the mode in which the plans for public buildings shall be adopted. The Act which directed work on the Branch Prison to be resumed, having authorized the Board to adopt the plan and specifications submitted to the legislative committees on State Prisons by Mr. Bennett, and the Board, in pursuance of such authority, having adopted such plan and specifications, it was unnecessary to advertise for plans as provided for in the Act of March 23d, 1876.

In pursuance of Section 3 of the Act of March 23d, 1876, the Board advertised for sealed proposals for furnishing all materials and doing all work, mechanical or otherwise, necessary to the completion of the Branch State Prison, according to the plan and specifications which the Board had adopted.

At the time appointed, July 13th, 1878, the Board met in the Executive Office, State Capitol, to open and consider the bids which had been received.

The bids were:

Hughes & Dudgeon's	$220,000
H. G. Livermore's	212,000
Dennis Jordan's	161,500

As the Board was not full, the Lieutenant Governor not being present, they adjourned to meet in San Francisco on the 17th inst., to further consider the bids and award a contract. At the adjourned meeting on July 17th, 1878, the Board awarded the contract to Dennis Jordan, his bid being the lowest, and accompanied by a certified check for ten per cent of its amount, as required by the advertisements soliciting bids.

On the 25th of July ensuing, Mr. Jordan entered into a contract, on the basis of his bid, for the completion of the Branch State Prison, according to the plan and specifications adopted by the Board, and now on file in the office of the Controller.

In such contract he stipulated to commence work on the said Branch State Prison within thirty days from the 17th day of July—the date on which the contract was awarded him—and to complete it within fifteen months from such date. The contract is on file in the office of the Controller of State, and a copy of it will be found in the minutes of the Board.

A. A. Bennett was appointed Architect at a salary of $250 per month, his services and pay to commence on the 25th of July, 1878.

James W. Duncan was appointed Superintendent, on the part of the State, at a salary of $200 per month, his services and pay to commence on the 26th of July, 1878.

The contractor commenced work on his contract at or about the time the terms of the contract required that he should. Owing, however, to the lack of the necessary capital to push the work vigorously, or to some other cause, the progress made in its execution was

very slow. The want of the necessary capital was, we think, the principal if not the sole cause of the slow progress made with the work. The work was frequently interrupted by the creditors of the contractor, who placed attachments on the tools, machinery, etc., employed in prosecuting the work. Some time in the month of January, 1879, the workmen also refused to work more till the Board made an arrangement with the contractor by which he agreed to assign to a member of the Board a sufficient sum out of the award which should be made to him for the material furnished and labor done in any month, to pay the workmen their wages earned during such month. This arrangement was consummated about the 1st of February, and before the contractor had been paid for his work and material for the month of January.

Mr. Beck was the member of the Board selected to receive the assignments from the contractor agreed upon, and to pay therefrom to the workmen, at the commencement of each month, their wages earned during the preceding month. The first assignment made to Mr. Beck by the contractor, was out of his award for material furnished and work done during the month of January. It was sufficient not only to pay the laborers their wages for the month of January, but also to pay them all balances on their wages earned before January and remaining yet unpaid; and Mr. Beck drew from the treasury the money thus assigned to him, and, proceeding to the site of the Branch Prison, paid to the laborers the wages due them for the month of January; he also paid all properly authenticated claims presented to him for wages earned prior to January, though the persons presenting such claims had previously signed receipts which released the Directors from all obligations to withhold from the contractor any sums due him for the purpose of securing the payment to them of their wages. If any person did not receive at that time the wages due him, whether such wages had been earned in January, or prior thereto, it was his own fault. All were notified that they had but to present their claims for wages, properly authenticated, to secure their payment.

It may be proper, at this point, to remark that the Board, in order to secure to the laborers the payment of their wages from the contractor, had taken the precaution to have inserted in the contract a stipulation that the contractor should not be entitled to receive any payment on account of material furnished or work done on his contract till he should furnish to the Directors satisfactory receipts, vouchers, or releases, showing that he had paid to the mechanics and laborers employed by him all sums due them for labor performed on his contract. In pursuance of this clause in the contract, the Board had, in each instance, before paying the contractor any money due him on his contract, required him to bring receipts from the mechanics and laborers employed by him, acknowledging the receipt of their wages for the period in which his claim against the State had accrued. It seems, however, that many of these persons were induced to sign such receipts before actually receiving their wages, on the contractor giving them his due-bills for the amount of the wages, supplemented by his promise to pay such due-bills as soon as he should receive from the State the amount due him, which he would be enabled to do by presenting to the Board their receipts for their wages during the month in which his claim had accrued. But as the contractor, after obtaining receipts from his laborers, which enabled him to draw

from the State the amounts due him, was slow to fulfill the promises on which such receipts had been obtained, a general discontent among the laborers sprung up, which culminated, as above noted, in their refusal to continue longer at work unless the Directors should, in some way, guarantee the payment to them of their wages at the end of each month, without risk or trouble to themselves.

Hence the arrangement by which the contractor was to assign to Mr. Beck a sufficient sum out of the award for material furnished and labor performed in each month to pay the wages of the laborers during such month; also, the arrangement by which he was assigned a sufficient sum out of the moneys due the contractor for labor and material furnished, in January to pay all claims for wages which had accrued during the month of January or prior thereto. From February till June, both inclusive, the contractor, at the beginning of each month, assigned to Mr. Beck a sufficient sum out of his award for material and labor furnished during the preceding month to pay the wages of the laborers during such month; and Mr. Beck, within a few days after the beginning of each month during this period, went to the Branch Prison and paid the laborers thereon their wages for the preceding month.

The Board did everything in their power to induce the contractor to proceed more rapidly with his contract. Through the lack of capital, however, he was compelled to contract debts, and, not being able to pay when the debts became due, his creditors were almost constantly harassing him with suits, and interrupting the work by attaching his tools and machinery. Under assurances from the contractor, constantly repeated, that he was expecting financial aid from his friends which would enable him to proceed with his contract and complete it within the prescribed time, and being most unwilling to embarrass him in the prosecution of the work as long as there might be any ground for hope that he would eventually be able to proceed with and complete it according to stipulation, and most anxious to avoid, if possible, the responsibilities which they must assume if they should proceed to act in pursuance of the authority conferred on them by Section 12 of the Act of March 23d, 1876, the Directors bore with the contractor till it became evident, beyond all peradventure, that he would not complete, or anywhere near complete, his contract within the time prescribed.

Up to the 1st of April, 1879, more than seven months from the commencement of the work and half of the time in which the whole work was required to be done, the contractor had, according to the estimates of the architect, furnished material and labor only to the value of $19,037 11. The Board, now fully satisfied, not merely that the work was not prosecuted with that energy and vigor which the contract required, but also that the contractor would not, if left to himself, prosecute it with such energy and vigor, resolved to assume and exercise the powers conferred on them by Section 12 of the Act "concerning contracts on behalf of the State, in relation to the erection of buildings," etc., approved March 23d, 1876.

Accordingly, in pursuance of the provisions of the said Act, the Board made an order on April 1st, 1879, requiring and directing the contractor, Dennis Jordan, to place not less than one hundred and fifty men, including mechanics and laborers, in such proportions as the exigencies of the work might require, at work on the Branch

State Prison, and to keep not less than that number continuously at work thereon.

This order was not complied with by the contractor, for the reason, as we believe, that he was unable to comply with it for the want of the necessary capital.

He was again sued by his creditors, and all his tools, machinery, and other property used in the construction of the prison were placed under attachment.

It now became apparent to the Board that the contractor could not furnish the material and labor necessary to proceed with and perform his contract, and that it would be necessary for the Directors themselves to employ, in pursuance of law, such force of workmen and furnish such material as might be required to complete such contract. Accordingly, on May 13th, 1879, the Board passed another order, requiring and directing the contractor to place on the work such force of men, in addition to the one hundred and fifty which he had previously been ordered to place thereon, and also to procure such material in addition to what he already had, as the Board had determined, after making careful estimates, would be necessary to enable him to comply with his contract. (For particulars of this order see minutes of the Board.) It was not expected that he would obey this order, but it was necessary to make it, as, under the law, it is only on the refusal or failure of the contractor to comply with such order of the Board that the latter are authorized to do what the former was ordered but failed to do.

As already stated, the contractor had not, up to May 13th, complied with the order made on April 1st, requiring him to employ and keep employed on the work a force of not less than one hundred and fifty mechanics and laborers. On May 14th his machinery, tools, and other property used in carrying on the work were attached and all work on the building, stopped; and thereafter he was wholly unable to comply with the requirements of the Directors, or to do any more work on his contract.

On May 23d, the Board of Directors employed William Johnston as foreman of the stone-work at the prison, and authorized him to employ and put to work, at the various kinds of labor necessary in the erection of the stone-work of the building, a force of a hundred and fifty men. He commenced work at once; but at first he employed only a small force, on account of not having sufficient machinery and tools to enable him to employ a larger force to advantage. On May 30th, all the tools, machinery, and other property belonging to the contractor, and used by him in doing work on his contract, were sold at Sheriff's sale. The Board of Directors purchased them.

Among the property, other than machinery and tools, which the Board purchased at such Sheriff's sale, was a "boarding house," located on the prison grounds, which the contractor had erected, so as to have the necessary facilities for boarding his workmen. The purchase of this house by the Board was made subject to a mechanics' lien, on which a judgment has since been obtained for $902 88, exclusive of interest and costs of suit. This judgment has not yet been satisfied.

At this point a controversy arose between the Board of Directors and the contractor, as to the rights of the contractor: 1st, in relation to the tools, machinery, etc., which the Directors had purchased at the Sheriff's sale. The contractor claimed that as he and his bonds-

men would be charged with the amount paid for the tools, machinery, etc., the purchase of them must be held to have been made for his use. He accordingly demanded to be put in possession of them, that he might employ mechanics and laborers and proceed with his contract. His demand was not acceded to by the Board; and, 2d, in relation to the force placed on the work by the Board of Directors: The contractor claimed that such force must be subject to his commands and must work under his directions. He claimed the right to discharge any person or persons whom the Directors or their agent might employ, if he should deem such person or persons for any cause unfit or improper persons to be employed. The Board did not concede his right to any voice as to whom they should or should not employ; nor his right to exercise any control or direction of the men whom they should have in their employ; 3d, in relation to the place from which the rock should be taken with which to complete the prison. The contractor claimed the right to forbid the Directors to take rock from quarries other than the one from which he had taken what rock he had used. This claim was also disregarded by the Board.

The contractor had, prior to his discontinuance of labor on the prison, made a contract with Gutenberger & Co. to do the iron work required by his contract, and one with J. J. Gleason to dô the plumbing. These contracts were permitted to stand, and have been carried out on the part of the State by the Board.

After the purchase of tools, etc., at the Sheriff's sale mentioned above, and after the date at which the contractor was required to put on an additional force, and purchase and procure additional material, in pursuance of the order of the Board of Directors passed on May 13th, the Directors caused to be placed on the work a large force of men, with the view of completing it within the time prescribed in the contract with Dennis Jordan. It became necessary, in order that this additional force might be employed to advantage, to procure, at a very considerable expense, additional tools and machinery. It was believed, also, to be both necessary and in the interest of economy to take rock from other quarries than the one from which the contractor had taken rock. And to do this it was necessary to build a railroad for a very considerable distance, at quite a heavy expense. The rails used for such purpose were old ones borrowed from the Sacramento and Placerville Railroad Company, the Directors paying the freight for transporting them from such places as they were at to the prison. They are still the property of the Company. The Directors were also at the expense of procuring a stationary engine with which to haul the cars up an incline. This is still the property of the State, and is nearly as good as new.

After prosecuting the work with a large force of men during the months of June and July, and with the utmost efforts at economy, the Board saw that it would be impossible to complete or anywhere near complete the prison with the appropriation made for the purpose. The Board, after full consultation with Mr. Bennett, the architect, Mr. Duncan, the Superintendent of construction on the part of the State, and Mr. Johnston, the Directors' foreman of stone work, determined to modify very materially the character of some portions of the work, required by the specifications of the architect. The changes determined on by the Board did not alter or in any way

affect the plan of the building, but went only to the way in which that portion of the work to which they related should be done.

The plan of the building embraced three hundred and twenty-eight cells. Of these only about one hundred were built. The architect's specifications required that the partition walls between the cells should be of dimension stone, pene-hammered. The first change ordered was that these partition walls should be built of rubble work, instead of dressed dimension stone.

The specifications of the architect required that the floors of the cells, both of the lower and upper tiers, should be of dressed granite slabs, extending the whole length of the cell. The second change ordered was that, instead of granite slabs for floors in the lower tier of cells, composition stone should be used; and instead of granite slabs for the floors in the upper tier of cells, quarter-inch plate iron, properly stayed and braced, should be used.

The specifications of the architect required that the floors of the prisoners' kitchen, dining-room, laundry, etc., should be of dressed granite slabs. The third change ordered was that these floors should be made of asphaltum, properly prepared, instead of such granite slabs.

The specifications of the architect required that the rooms intended for the use of the officers should be finished with cornices, center pieces, etc. The fourth change ordered was that such cornices, center pieces, etc., should be dispensed with.

It was believed by the Board, at the time they ordered these changes in the character of the work, that the prison could be completed with the appropriation already made for the purpose.

The contractor not having let the contract to any one for doing the carpenter work, the Board advertised for bids for doing such work, and furnishing the material therefor. In response to advertisements bids were received, as follows:

Carle & Croly's bid was	$17,167
E. M. Chatterton's bid was	16,750
James M. Kelly's bid was	19,000
F. Crowley's bid was	17,250
W. F. Knox's bid was	17,500
E. Pearson & Company's bid was	15,300
M. W. Finnell's bid was	16,484
Terrill & Slaven's bid was	12,275

The contract was awarded to Terrill & Slaven, who gave the necessary bond for the faithful performance thereof, and who are in good faith performing it.

The plate iron floors of the cells of the upper tier was put in by James McGuire, at $44 a floor.

The bids for this work were as follows:

Jonathan Kittridge's bid was	$44 75 per cell.
John L. Cook's bid was	46 60 per cell.
C. M. Leavitt's bid was	45 00 per cell.
James McGuire's bid was	44 00 per cell.

The glazing, including all materials, has been let to Whittier, Fuller & Co. for $613.

The Board received and opened bids on November 5th, for the plastering required by the specifications, but did not award a contract.

Upon making an estimate of the probable cost of the stone work yet to be done, of what would become due on contracts already let, and of other expenses which could not be avoided, the Board became satisfied that such contract, if made, would create a liability, in conjunction with those already created and those which must be created, in excess of the appropriation.

After the completion of the iron work, the carpenter work, and the plumbing, which are now being done under contracts already let, as hereinbefore stated—and for the payment of all sums which will become due on such contracts there is a sufficient unexpended balance in the appropriation already made—there will still remain unperformed on Jordan's contract, the plastering, the floors of certain cells, the floors of the corridors, and the floors of the kitchen, dining-room, etc. For the completion of this latter work a further appropriation will be required.

The rights of the State, and the liabilities of the contractor and his bondsmen, growing out of the failure of the contractor to comply with the requirements of his contract, are questions which we are compelled to leave for adjustment to our successors.

RECEIPTS AND DISBURSEMENTS.

The receipts and disbursements of the Board have been as follows :

Receipts.

From appropriations	$205,494 73
From rent of house	315 00
From sale of granite	82 12
Total	$205,891 85

Disbursements.

Warrants on the Treasurer have been drawn in favor of:

A. A. Bennett, Architect, for	$5,300 00
J. W. Duncan, Superintendent, for	3,245 00
R. R. Provines, drawing contract, for	150 00
John Odell, for sundries, for	1,792 00
D. Jordan, on contract, for	28,246 79
D. Jordan, for work and material other than on contract, for	3,786 45
John Liness, surveying, for	20 00
W. C. Hawkins, surveying and map, for	150 00
Ed. Christy, for hoisting engine, for	850 00
F. R. Hogeboom, Clerk of Board, for	375 00
F. R. Hogeboom, cash expended for sundries, for	50 47
Turner, Kennedy & Shaw, lumber, for	598 60
H. G. Livermore, for merchandise purchased, for	1,363 71
T. P. H. Whitelaw, for derricks, etc., for	1,225 20
Neubourg & Lages, for oatmeal, for	212 50
Marcus C. Hawley & Co., hardware, for	1,455 77
Huntington, Hopkins & Co., hardware, for	3,527 29
M. M. Drew, tools, etc., bought at Sheriff's sale, for	5,350 00
Sacramento and Placerville Railroad Company, for freight, railroad ties, etc., for	1,770 09
Wm. Gutenberger & Co., on contract and for other work, for	15,891 71
John Ryan, for brick, for	480 00
H. T. Holmes & Co., for cement and lime, for	2,912 02
Birch, Argall & Co., for engine, boiler, etc., for	4,941 10
A. Doble, for merchandise, for	1,610 55
N. L. Drew & Co., for lumber, for	733 03
Root, Neilson & Co., for derrick gearing, etc., for	282 61
Jas. McGuire, iron cell floors, for	5,280 00
J. J. Gleason, on contract for plumbing, for	2,128 50
San Francisco Chronicle, for advertising, for	3 00
Davis & Crowell, for cement, for	522 50
Terrill & Slaven, on contract, for	10,710 82
Whittier, Fuller & Co., paints, oils, etc., for	44 00
Natoma Water and Mining Company, for tools, etc., for	767 68
R. S. Carey, for yoke of cattle, for	166 75
Joseph Cook, for buggy, for	100 00
Spaulding & Fenwick, for iron pipe, for	468 50
	$106,511 64

Warrants were drawn on the Treasurer in favor of Board of Directors for	$89,837 77	
Board received for rent	315 00	
Board received for granite	82 12	
		$90,234 89
By cash paid wages	$85,394 07	
By cash paid Gutenberger & Co.	736 25	
By cash paid Thos. Beck, expenses	135 75	
By cash paid Wm. Irwin, expenses	48 00	
By cash paid F. R. Hogeboom, expenses	6 00	
By cash paid sundries at Folsom	3,914 82	
		$90,234 89

SUMMARY.

By warrants	$106,511 64	
By cash	90,234 89	
By balance in fund	9,145 32	
		$205,891 85

WILLIAM IRWIN, Governor,
——— ———, Lieutenant-Governor,
THOMAS BECK, Secretary of State,
Board of Prison Directors.

MAJORITY AND MINORITY REPORTS

OF THE

Joint Committees of Finance of the Senate,

AND OF

WAYS AND MEANS OF ASSEMBLY,

ON SUBSTITUTE BILL FROM EACH FOR

Senate Bills Nos. 101, 120, 188, 196, 199, 206, and 280.

1*

MAJORITY REPORT.

Mr. President: Your Committee upon Revenue have had under consideration the question of providing revenue for the support of the government of the State, and the various bills presented to the Legislature and referred to the committee upon that subject. The committee has not been able to agree, but the majority concur in a bill which is presented with this report, and is entitled "An Act to amend sections three thousand six hundred and seven, three thousand six hundred and seventeen, three thousand six hundred and twenty-seven, three thousand six hundred and twenty-eight, three thousand six hundred and twenty-nine, three thousand six hundred and thirty, three thousand six hundred and thirty-four, three thousand six hundred and forty, three thousand six hundred and forty-one, three thousand six hundred and forty-three, three thousand six hundred and fifty, three thousand six hundred and fifty-one, three thousand six hundred and fifty-two, three thousand six hundred and sixty-three, thousand six hundred and seventy-three, three thousand six hundred and seventy-eight, three thousand six hundred and seventy-nine, three thousand seven hundred and thirty, three thousand seven hundred and fifty-two, three thousand eight hundred and thirty-nine, and three thousand eight hundred and sixty-one, and to add a new section, to be numbered three thousand six hundred and sixty-four, to, and to reënact section three thousand seven hundred and seventeen, of title nine, of the Political Code, to provide revenue for the support of the government of the State."

The first question which presented itself to the committee was, whether the legislation required upon this subject ought to be embodied in an independent Act, or made a part of the Political Code. That Code already contained a complete revenue law—one which had been in force for several years; had been, to some extent, judicially construed and interpreted; and had in the main proved satisfactory to the State, and adequate to the accomplishment of the purposes for which it was enacted. The committee, therefore, deemed it best to take that law as the basis of its action, and to propose only such amendments as were suggested by the experience and reflection of the committee, or were required to harmonize the law with the recently adopted Constitution of the State.

The first amendment proposed is to section three thousand six hundred and seven of the Political Code.

By this amendment this section is made to declare that all property is subject to taxation, except that exempted by the laws of the United States, or by the Constitution of this State. The section further provides that no property shall be subject to double taxation, or to be twice charged or assessed for the same tax, and that moneys on deposit with any banking corporation, and stock or shares of stock issued by any corporation organized under the laws of the State, and

held by bona fide residents of the State, shall be deemed and treated, for the purposes of assessment and taxation, as a part of the property of such corporation.

The second amendment proposed is to section three thousand six hundred and seventeen. Its object is to enlarge the definition of the term real estate contained in that section, so as to include "the interest in land held or acquired by virtue of a mortgage, deed of trust, contract, or other obligation affecting land, by which a debt is secured." This amendment is obviously required by the provisions of the Constitution declaring that mortgages, deeds of trust, and other instruments securing the payment of debts, shall be treated as an interest in the property affected thereby.

The third amendment is to section three thousand six hundred and twenty-seven, and, if adopted, it will incorporate into that section the provisions of sections two, four, and five, of article thirteen of the Constitution, requiring that "cultivated and uncultivated land, of the same quality, and similarly situated, shall be assessed at the same value;" declaring the mode in which mortgages, deeds of trust, and other contracts by which debts are secured, shall be assessed, and the respective rights and obligations of mortgagors and mortgagees in regard to the taxes imposed; and also providing that all contracts made after January first, eighteen hundred and eighty, by which a debtor is obligated to pay any tax or assessment on money loaned, or on any mortgage, deed of trust, or other lien, shall, as to any interest specified therein, and as to such tax or assessment, be null and void.

The fourth amendment is to section three thousand six hundred and twenty-eight, and its chief object is to direct the Assessor to assess all property to the person, firm, or corporation by which it was owned, or in whose possession or control it was at twelve o'clock M. of the first Monday in March, as required by the Constitution. This amendment also enacts that no mistake in the owner of real estate shall invalidate the assessment thereof.

Section three thousand six hundred and twenty-nine of the Political Code is the subject of the fourth amendment.

This amendment directs the Assessor to exact a statement, in the form prescribed by the State Board of Equalization, from each firm, person, and corporation. The taxpayer in this statement, in addition to the matter formerly required, "must separately state and describe mortgages, deeds of trust, contracts, and other obligations by which debts are secured, stocks issued by corporations, credits for moneys deposited with savings and loan corporations, or other corporations doing a banking business, all other credits, debts owing by such person, firm, or corporation, to bona fide residents of the State, or to firms or corporations doing business in the State."

The sixth amendment proposed is to section three thousand six hundred and thirty, regarding the affidavit to be exacted by the Assessor. Besides the matter heretofore required, this affidavit must state that the list made by the affiant contains a full and correct statement of all property subject to taxation, which he owned or had in his possession, or under his control, at twelve o'clock M. on the first Monday in March, and that the debts therein stated to be owing by him are owing to bona fide residents of the State, or to firms or corporations doing business in this State.

The seventh amendment is designed to conform section three

thousand six hundred and thirty-four to the provisions of section three, of article thirteen, of the Constitution, directing the assessment of surveyed lands in sections, or fractions of sections, and requiring the "Legislature to provide by law for the assessment in small tracts, all lands not sectionized by the United States Government."

The eighth amendment is to section three thousand six hundred and forty, and, if adopted, will prohibit the assessment of the property of a firm to the individual members thereof, and of deposits to the individual depositor thereof, and of stock to the individual holders thereof, it being the policy of the amendments proposed by the majority of your committee to assess all the property of a firm to the firm, and all the property, franchises, and deposits of each corporation to such corporation.

By the ninth amendment, provisions are added to section three thousand six hundred and forty-one, requiring the assessment of franchises, and specifying the place and mode in which such assessment must be made; authorizing the State Board of Equalization to apportion the valuation of mortgages, and other instruments affecting lands situated in two or more counties, or in two or more subdivisions or districts of the same county; providing for deductions for the amounts actually paid on any mortgage on or before the first Monday in March, and, in those cases where the amount of a mortgage or deed of trust is in excess of the cash value of the land, declaring that the mortgage or deed of trust must be assessed at its full value, and that the realty shall not be assessed.

Section three thousand six hundred and forty-three, as proposed to be amended by the tenth amendment, provides for the assessment of ferries, and of franchises, water-craft, and toll bridges connecting more than one county.

The eleventh amendment is to section three thousand six hundred and fifty. The new requirements proposed are: First, that the form of the assessment book shall be as prescribed by the State Board of Equalization; second, that in the case of mortgaged property the roll must show the value of the mortgage and the value of the remainder after deducting the value of the mortgage; third, that if all the taxable property of a corporation is assessed, then that its stock must be assessed to the owner and holder thereof only in the amount which its market value exceeds its par value; fourth, that credits for deposits with banking corporations doing business in this State, all the property of which has been assessed, must be assessed to the owner and holder thereof only in the amount in which the value of such credits exceeds the amount of the money so deposited; fifth, that in assessing unsecured credits, there must be deducted therefrom the unsecured debts due from the owner thereof; sixth, that taxable improvements shall be assessed, though situate on lands not subject to taxation.

The twelfth amendment is to section three thousand six hundred and fifty-one, and its object is to permit the State Board of Equalization to prescribe the form of the assessment book, and to provide that until the Board prescribe such form the book shall be in the form heretofore used.

Section three thousand six hundred and fifty-two is proposed to be amended in some unimportant particulars, in respect to the oath

to be taken by the Assessors and their deputies, on the completion of the assessment book.

By the provisions of the present Constitution, railroads lying in two or more counties must, with the franchise and rolling stock thereof, be assessed by the State Board of Equalization. Hence, section three thousand six hundred and sixty-three is amended by striking out the provisions regarding the assessment of such railroads and their rolling stock, as the law in regard to such assessments should be embodied in that portion of the Code defining the powers and prescribing the duties of the State Board of Equalization.

The fifteenth amendment is to section three thousand six hundred and seventy-three. Its object is to vest the County Boards of Equalization with more ample powers than those heretofore confided in them by statute, and to enable them to determine all complaints in regard to the assessments of property, the deduction of debts from credits, the valuation of stocks, and of credits for moneys deposited with savings and loan and other banking corporations.

Section three thousand six hundred and seventy-eight is, by the sixteenth amendment, enlarged so as to require the Recorders in the several counties to furnish the Assessor with complete abstracts of all mortgages, deeds of trust, etc., remaining unsatisfied at twelve o'clock M. of the first Monday in March, and also to require the Board of Supervisors to furnish the Recorders with clerical assistance when necessary to enable them to comply with this section.

Section three thousand six hundred and seventy-nine of the Political Code provides for assessments to be made, after the completion of the regular assessment, of all property not already assessed, but declares that "*no person must be assessed, under this section, except a resident of the county.*" The seventeenth amendment, proposed by your committee, is to omit this last clause.

The eighteenth amendment consists of the reënactment of section three thousand seven hundred and seventeen of the Political Code.

The bill reported herewith amends section three thousand seven hundred and thirty, so as to require the County Auditor to enter upon the assessment roll the changes ordered therein by the State Board of Equalization.

The twentieth amendment is to strike out the words "Probate Judge," in section three thousand seven hundred and fifty-two, and insert, in place thereof, the words "Superior Court;" while the twenty-first and twenty-second amendments are to sections three thousand eight hundred and thirty-nine and three thousand eight hundred and sixty-one, and their object is to conform the provisions of those sections relating to poll taxes to the provisions of the present Constitution on the same subject.

It is apprehended that the chief ground of opposition to the bill presented herewith will be based upon the fact that its first section declares that no property shall be subject to double taxation, and that its subsequent sections are conceived in consonance with this declaration. The double taxation which is thus sought to be obviated arises mainly, if not exclusively, in reference to the taxation of stocks in corporations formed and doing business in this State, and of moneys on deposit with the savings and loan corporations of the State.

That to tax at its full cash value the franchise and all the real and personal property of a corporation, is an effectual and complete tax-

ation of all the values belonging to such corporation, whether tangible or intangible, is beyond dispute. It is equally beyond controversy that the stock issued to the stockholders of the corporation is but a certificate showing the interest which the holder has in the entire assets of the corporation, just as a deed is merely the evidence of the interest which the grantee has acquired in the property described therein. If the government saw fit it might, perhaps, direct the tax to be assessed and levied upon either the land or the deed, but no one will contend that an *ad valorem* tax on *both* could be made consistent with the principles of natural equity, or the plain mandate of the Constitution, that "all property shall be taxed in proportion to its value, to be ascertained as provided by law."

If five persons own a farm or a manufactory, as tenants in common, worth one hundred thousand dollars, there is no doubt as to the mode of its assessment, and that such assessment can in no form be made to exceed that sum. If these five men choose to form a corporation, to fix the value of their property at one hundred thousand dollars, and to name their capital stock at the same sum, it is evident that they have created nothing of value; that the property and its worth are precisely the same as before. The government, if it prefers that mode, may treat the capital stock as the basis of assessment and taxation, but if it does so, it must not again value and assess that which is the sole thing giving the stock any value whatever. In other words, if the farm or manufactory is assessed at one hundred thousand dollars, and the stock representing it at another one hundred thousand dollars, while no advance has been made in the assessed value of other farms or manufactories, this is a clear case of an assessment of property otherwise than "in proportion to its value."

If A has one thousand dollars, and loans it to B, it is clear that the assessment of this property, as a mortgage or otherwise to A, for one thousand dollars, is a just and constitutional assessment, because in proportion to the value of the property. But if C, having one thousand dollars, deposits it with D, a savings bank, which loans it to E, and the result of these transactions is two assessments, viz: one to C and one to D, and each for one thousand dollars, here is a mode of assessment not in proportion to value, for C's one thousand dollars is made to contribute to the support of the government, during the same year, twice as much as A's one thousand dollars.

If, as a question of policy, either the savings and loan societies, or any other class of corporations, ought to be exterminated, then the legislation for that purpose should be honest, straightforward, and professing to pursue that end, and not enacted under the guise of assessing all property in proportion to its value.

The mode of assessment proposed by the majority of your committee does not exempt any corporation from the taxation of any property whatsoever held by it. On the contrary, it provides for the assessment against each corporation of its franchise, its real and personal property, its deposits and mortgages, and all credits held by it. When these assessments are made, and the taxes thereon collected and paid, it must follow that such payment diminishes the profits of the corporation, and is indirectly borne by the stockholders and depositors, by being deducted from the fund out of which their dividends are paid. Having thus paid one tax, and thereby contributed to the revenue of the State, "in proportion to the value of their prop-

erty," shall there be exacted of the depositors another tax of the same amount, levied upon the same property, in the same year, and for the same purposes?

No honest business can be successfully conducted in this State if it labors, directly or indirectly, under the burdens of double taxation. The imposition of such taxation necessarily destroys the subject taxed. The depositors in our savings banks are mainly persons who have not acquired any considerable amount of wealth, who are seeking by industry and frugality to amass a sufficient competency with which to secure a home or to provide against want in sickness or in old age, and who do not feel competent to directly keep and invest their savings to the best advantage. To needlessly legislate against this class of people is worse than foolish; it approaches to the dignity of a crime. A tax on the market value of the capital stock of a corporation, over and above the value of its real and personal property, has sometimes been supported on the ground that it is a tax on the corporate franchise.

But section three thousand six hundred and forty-one, as proposed to be amended by the majority of your committee, expressly provides for the assessment of *franchises* at their full cash value. Any further assessment of franchises would therefore necessarily result in double taxation.

Perhaps, however, the opposition to the bill reported herewith will ultimately be supported, on the sole ground that the Constitution necessarily and unavoidably exacts double taxation of the property of corporations having a capital stock, and also of the deposits in savings and other banks.

In seeking for a correct interpretation of the provisions of the Constitution on this subject, it is well to remember that all presumptions are against duplicate taxation. Thus, Judge Cooley, at page one hundred and sixty-five of his work on taxation, says: "It has very properly and justly been held that a construction of the laws was not to be adopted that would subject the same property to be twice charged for the same tax, unless it was required by express words of the statute, or by necessary implication. It is a fundamental maxim in taxation that the same property shall not be subject to a double tax, payable by the same party, either directly or indirectly; and where it is once decided that any kind or class of property is liable to be taxed under one provision of the statutes, it has been held to follow as a legal conclusion that the Legislature could not have intended the same property should be subject to another tax, though there may be general words in the law which would seem to imply that it may be taxed a second time. This is a sound and very just rule of construction, and it has been applied in many cases where, at first reading of the law, a double taxation might seem to have been intended."

So far as the Constitutional Convention went into the details of taxation it sought to avoid the duplicate assessment of the same property. It declared that the assessments should be made as of twelve o'clock M. of a certain day, and thus prevented the various assessments that might otherwise have been occasioned by changes in the form, location, or ownership of the same personalty during the period in which assessments throughout the State were being made. It required that credits, secured by mortgage, should be deducted from the value of the property affected thereby. It authorized the

Legislature to provide for the deduction from unsecured solvent credits of the unsecured debts owed by the holders of such credits to residents of this State; and it stated at the commencement of its article on the subject that "all property in the State, not exempt under the laws of the United States, shall be taxed in proportion to its value,to be ascertained as provided by law." Under this provision, as we understand it, it is the duty, as well as the right, of the Legislature to enact laws which will, as far as possible, prevent all double taxation, for if there be double taxation it can never coexist with the taxation of property in proportion to its value.

The former Constitution of this State declared that "taxation shall be equal and uniform throughout the State; all property in this State shall be taxed in proportion to its value," etc. For more than a quarter of a century the statutes enacted under that Constitution, governing the assessment of stock, were substantially as follows: "The owner or holder of stock in any private or incorporated company or association, the entire capital of which is invested in property which is assessed, or the capital of which is assessed, shall not be assessed individually for his stock in such company or association," etc. (Statutes 1854, p. 104, Sec. 62; St. 1857, p. 328, Sec. 6; St. 1861, p. 423, Sec. 16, and Political Code, Sec. 3640.) During that quarter of a century many cases were determined involving the interpretation of that Constitution upon the subject of taxation, but, so far as we are aware, it was never held or claimed that the provisions of these several statutes were in any way in conflict with the mandate of the Constitution requiring all property to be taxed.

In New Hampshire, when it was attempted, after taxing the whole property of corporations, to further tax the capital stock, the Supreme Court said: "A taxation of the shares at their appraised value, would, in fact, be a double taxation; once to the corporation itself, and again to the corporators, which would be unjust, oppressive, and *unconstitutional.*" (Smith vs. Burley, 9 N. H. 423, quoted and approved in Savings Bank vs. Nashua, 46 N. H. 398.)

An article of the Bill of Rights in Maryland declares that "every person in the State ought to contribute his proportion of the public taxes for the support of the government, according to his actual worth in real or personal property." Under this article the Supreme Court declared that, "although the State may elect to tax either the capital stock, or the real and personal property of the company, *yet it cannot tax both.*" (State vs. Cumb. and Penn. R. R. Co., 40 Md. 22, 52.) Under the same article, the same Court had previously held that no double taxation could be imposed on deposits in savings banks. (State vs. Sterling, 20 Md. 502.)

It is certain that when the present Constitution was under discussion before the people, its advocates contended that it neither required nor permitted any double taxation in the case either of deposits or of capital stock. We shall quote some of the views expressed at that time to show the construction given to the Constitution by its friends, and that the measures contained in the bill reported herewith are in harmony with that construction. Thus, the San Francisco Chronicle, in an editorial published April twenty-second, eighteen hundred and seventy-nine, said: "One of the misrepresentations most persisted in by the opposition to the New Constitution is that it proposes to tax deposits in savings banks twice—once as to credits on individual depositors, and again as credits of the banks.

Thus, they say, if Jones has one thousand dollars deposited in the Hibernia Savings Bank, he will be assessed upon his pass-book for that sum as a creditor of the bank, and the bank will be also assessed for the same property as a part of its credits at interest. The argument continues that this will so decrease the profits of the deposits as to discourage savings, break up the savings banks, and bring general ruin upon the country. The argument is so utterly unfounded that it is hardly worthy of a reply, especially as we have already answered it several times. But, because it is still harped upon, we will notice it again.

"The Constitution establishes this fundamental rule: 'All property in the State not exempt under the laws of the United States shall be taxed *in proportion to its value, to be ascertained as provided by law.*' Under the general rule it must be remembered that the leading idea is *proportionate value.* The object clearly is to compel each citizen to contribute in proportion to the value of the property which the law protects for him. This means equal taxation—that is, *taxation according to ability to pay.* It is susceptible of no other construction. It is the rule laid down by Adam Smith, and approved by all subsequent writers of acknowledged authority. And because the judgments of men are fallible, because Assessors are apt to differ as to the mode of determining values, the Constitution clothes the Legislature with power to provide for ascertaining the value of property. The only limitation upon the power of the Legislature, in this respect, is that the values should be proportionate, and that all property shall be taxed, whether tangible or intangible. In the latter class, as will be seen by reference to the definition of the word property in the Constitution, fall credits in banks. Now the Legislature may tax bank deposits in either of two ways. It may tax them to the individual depositors separately, or to the banks collectively, which are simply agents for the depositors. They are property having value, and certainly should pay taxes; but they cannot be taxed both to the banks and to the depositors. Why? Because that would be taxing the same property at twice its value, and not in proportion to its value. It would be just like taxing gas stock to the individual shareholders, and again to the corporation; or like taxing real estate in the hands of an agent, and again to the owner. It would be unequal, unjust, ridiculous, and clearly unconstitutional. The natural way to do would be to tax the deposits in the banks, and not tax the depositors individually."

The same questions had been thus previously discussed, in an article by an eminent member of the Convention, General Volney E. Howard, and published in the same paper, on April eleventh, eighteen hundred and seventy-nine:

"It has been developed by the press, that it is the salutary provisions of the proposed Constitution for the regulation of corporations, which has produced the violent opposition to its adoption. The motive is obvious. Under the provisions of the present Constitution, as construed by the Supreme Court, that mortgages and credits are not property for the purposes of taxation, the moneyed corporations, and the money changers, and stock gamblers, escape taxation nearly altogether. They naturally wish to continue this great boon of exemption from the burden of the State. They raise a false issue and clamor, by alleging that the Constitution, as proposed in taxing credits, imposes double taxation. They ignore the fact that the Con-

stitution declares that 'all property in the State shall be taxed in proportion to its value, to be ascertained according to law,' and to make assurance doubly sure, provides 'State and County Boards of Equalization, whose duty it shall be to equalize the valuation of the taxable property of the several counties in the State for the purposes of taxation,' and also that the Board is authorized and empowered 'to increase or lower the entire assessment roll or any assessment of property contained therein, so as to equalize the assessment of property contained in said assessment roll.' It is therefore clear that double taxation is impossible hereafter if the new Constitution shall be adopted. First, under this provision, if property should be doubly taxed, it would not be according to value, and if it appears on the face of the assessment, it would be void, and the Court would so declare; second, if it was so assessed, it would be the sworn duty of the Board of Equalization to reduce it to a single valuation. If a man deposits money in a savings bank, whether loaned or not, it could be taxed but once, whether taxed to the depositor or the bank, and whether taxed on the money deposited or on the loan. It is absurd to say there could be one tax on the pass-book and another on the money, whether loaned or not. The assertion is a false alarm created for a single purpose. Again, 'the value is to be ascertained as provided by law.' That is, as the Legislature may direct, and therefore it would be in the power of the Legislature to adopt a system which would prevent double taxation, if ever resorted to."

The same learned jurist, in a prior communication to the same paper, had called attention to the Maryland decisions hereinbefore cited, and had said: "The attempt to alarm the depositors in savings banks, with double taxation, is entirely disingenuous. If a party deposits money in a savings bank for loan, he is, in fact, the owner of the money, and the bank the agent or trustee, and whether loaned in his name or that of the bank, the tax will be on the loan or mortgage. It cannot be on both, because they are not two values."

In the same paper, on April thirtieth, eighteen hundred and seventy-nine, in an answer to the card of the Directors of the Hibernia Bank, it was said: "The new Constitution does not change the condition of either the depositor or the bank; the pass-book, as such, is not taxed; it is merely evidence of the amount of money on deposit; it is the deposit that is taxed, and this tax can be paid, as at present, either by the bank or the depositor. If paid by the bank, *the depositor is released;* if the depositor, the bank is released. *It can only be assessed once and paid once in each year.*"

Similar opinions were expressed in an editorial of the same paper, on the same day, and were very generally urged during the canvass by the friends of the proposed Constitution.

Having thus sought to show the bill herewith presented is in harmony with equity, with sound public policy, with the language of the Constitution, requiring taxation of all property in proportion to its value, and with the construction of that Constitution insisted upon by its advocates in the campaign preceding its adoption, we respectfully submit our proposed amendments to the consideration of the Senate and Assembly of the State.

E. H. PARDEE,
Chairman of Finance Committee of Senate.
WM. B. MAY,
Chairman of Committee on Ways and Means of Assembly.

MINORITY REPORT.

Mr. President: The minority of the Joint Committee of Finance of the Senate and Ways and Means of the Assembly, to whom were referred the various bills on revenue and taxation, hereby offer the annexed bill as a substitute for the bill recommended by the majority, and the said minority give the following reasons as their ground of disagreement:

The adoption of the minority's system of taxing stock would increase the taxable property of the State at least seventy-five millions of dollars, and to that extent lessen the rate of taxation.

Section three thousand six hundred and seven of the bill submitted by the majority appears clearly to violate section one, of article thirteen, of our Constitution, which requires all credits, claims, and demands, due or owing from banks or individuals, to be assessed alike.

And such discrimination in favor of banks and against individuals is alike unreasonable, and unjust, and unconstitutional, and, if made, would occasion a loss to the State of at least fifty millions of dollars of assessable property, and to that extent would increase the rate of taxation.

If the theory of assessing credits contained in the majority bill should be adopted, as people from all parts of the State, even from its most remote corners, deposit their money largely in the cities, or money centers, it would result in the reduction of assessments and revenue in all parts of the State, except where the principal banks are located and where the principal deposits are made.

Such a system, if adopted, would work great injustice; would tend to enrich the money centers, and to impoverish all other parts of the State.

One of the principal objections to the system of taxation contained in the bill of the majority, supported by a portion of the joint committee that has had under consideration the question of revenue and taxation, is that while it admits the right and duty of the Legislature to assess the stock of incorporated companies, it adopts a system of assessing premiums only—that is, the difference between the market value and the par value when the par value is less than the market value, which so seldom occurs that it renders the constitutional provision requiring stock to be taxed practically nugatory.

The system for the taxation of stocks contained in the minority bill is simple and intelligible in its terms, and, we submit, is in exact compliance with a just and liberal construction of the mandates of the Constitution itself, and will accomplish the purposes intended.

This system is expressed in section three thousand six hundred and forty of the minority bill, and is as follows:

Section 3640. Corporations, associations, and joint stock com-

panies having their principal place of business in this State, shall be assessed with the market value of their capital stock, after deducting therefrom the value of all other property assessed to them, and such capital stock shall not be assessed to the individual owners thereof.

The owners or holders of capital stock in corporations, associations, and joint stock companies, whose principal place of business is not within the State, must be individually assessed for such stock.

For the foregoing reasons, and for other reasons not necessary to mention, we recommend the adoption of the report submitted by the minority, and the passage of the bill herewith introduced.

SACRAMENTO, February 16th, 1880.

W. W. MORELAND,
A. B. CARLOCK,
FRANK A. LEACH,
L. G. MORSE,
R. F. DEL VALLE,
W. W. CUTHBERT,
MAX BROOKS,
C. HARTSON,
J. P. BROWN.

REPORT OF THE MINORITY

OF THE

Joint Committee of Finance of the Senate

AND OF

WAYS AND MEANS OF ASSEMBLY.

REPORT.

Mr. Speaker:

The minority of the Joint Committee of Finance, of the Senate, and Ways and Means, of the Assembly, to whom were referred the various bills on revenue and taxation, hereby introduce the annexed bill as a substitute for the bill recommended by the majority, and the said minority give the following reasons as their grounds of disagreement:

The adoption of the minority's system of taxing stock would increase the taxable property of the State at least seventy-five millions of dollars, and to that extent lessen the rate of taxation.

Section three thousand six hundred and seven (3,607) of the bill submitted by the majority appears clearly to violate section one (1) of article thirteen (13) of our Constitution, which requires all credits, claims, and demands, due or owing from banks or individuals, to be assessed alike.

And such discrimination in favor of banks and against individuals is alike unreasonable, and unjust, and unconstitutional; and, if made, would occasion a loss to the State of at least fifty millions of dollars of assessable property, and to that extent would increase the rate of taxation.

If the theory of assessing credits, contained in the majority's bill, should be adopted, as people from all parts of the State, even from the most remote corners, deposit their money largely in the cities or money centers, it would result in the reduction of assessments and revenue in all parts of the State except where the principal banks are located, and where the principal deposits are made.

Such a system, if adopted, would work great injustice—would tend to enrich the money centers and to impoverish all other parts of the State.

One of the principal objections to the system of taxation contained in the bill of the majority, supported by a portion of the Joint Committee that has had under consideration the question of revenue and taxation, is that, while it admits the right and duty of the Legislature to assess the stock of incorporated companies, it adopts a system of assessing premiums only; that is, the difference between the market value and the par value, which so seldom occurs that it renders the constitutional provision, requiring stocks to be taxed, practically nugatory.

The system for the taxation of stocks contained in the minority bill is simple and intelligible in its terms, and, we submit, is in exact compliance with a just and liberal construction of the mandates of the Constitution itself, and will accomplish the purpose intended.

This system is expressed in section three thousand six hundred and forty (3640) of the Minority Bill, and is as follows:

"Section 3640. Corporations, associations, and joint-stock com-

panies having their principal place of business in this State, shall be assessed with the market value of their capital stock, after deducting therefrom the value of all other property assessed to them, and such capital stock shall not be assessed to the individual owners. thereof." "The owners or holders of capital stock in corporations, associations, and joint-stock companies, whose principal place of business is not within the State, must be individually assessed for such stock."

For the foregoing reasons and other reasons not necessary to mention, we recommend the adoption of the report submitted by the minority and the passage of the bill herewith introduced.

W. W. MORELAND,
A. B. CARLOCK,
FRANK A. LEACH,
L. G. MORSE,
R. F. DEL VALLE,
Wm. W. CUTHBERT,
MAX BROOKS,
C. HARTSON,
J. P. BROWN, of Yuba.

Sacramento, February 16th, 1880.

REPORT OF ASSEMBLY COMMITTEE

—ON—

Agriculture, Mining, and Mechanic Arts College.

REPORT.

SACRAMENTO, March 31st, 1880.

MR. SPEAKER: Your Committee on Agriculture, Mining, and Mechanic Arts College, pursuant to authority granted them by the House on Saturday, March 20th, 1880, have visited the State University at Berkeley, and particularly the departments relating to agriculture and mechanical arts, and beg leave to submit the following report:

We found the Agricultural Department well and ably conducted, and as complete as could be expected with the time and facilities that the Faculty have had at their disposal.

The Mechanical Department is in a very crude condition, for the want of implements and necessary paraphernalia. This department should have a practical workshop fitted with tools and machinery, to unite theory with practice—machines and models selected as representatives of important departments of industry, machines and instruments used in experimenting, such as testing machines, brakes, indicators, etc., line-shafting, running-gear, belting, benches, shelves, etc. It is already provided with a five-horse power steam engine, one screw cutting lathe, and an upright drill, but these are of no practical use unless these various other machinery and implements are provided to make it complete and in proper condition to give a thorough course of instruction in that branch.

In order to perpetuate the Agricultural Department, which is of vital importance to the State, and make it more complete by providing necessary implements, etc., it will require an appropriation of five thousand dollars, which, in our judgment, will be necessary to carry them through the coming year. We would also suggest as equally necessary an appropriation of five thousand dollars for the Mechanical Department, which will make in all ten thousand dollars, divided equally between these two important branches of the University.

In summing up, we would state further, that on the whole these branches are creditably conducted, and the Faculty very enthusiastic in their work, and with the necessary aid from time to time the State will soon derive substantial benefits therefrom in developing two of its most important branches of industry.

J. L. YORK,
DANIEL FRINK,
H. K. BROWN,
ELIHU ANTHONY,
J. S. P. BASS,
CHS. MULHOLLAND,
J. J. McDADE,

Committee.

PETITION

RELATIVE TO

Removal of Obstructions in Pit and Fall Rivers.

TO THE LEGISLATURE, TWENTY-THIRD SESSION—1880.

PETITION.

To the Senate and Assembly of the State of California:

GENTLEMEN: We, your constituents residing in that part of the State of California composed of Modoc, Lassen, and Shasta Counties, which are drained by Pit and Fall Rivers and their tributaries, most respectfully petition your honorable body to enact such laws whereby an appropriation may be made, sufficient to remove the natural obstructions in said rivers, so that salmon may ascend the watercourses to their farthest sources, which would be from one hundred and fifty to two hundred miles of new spawning grounds, and would add greatly to the quantity in the Sacramento, and be a great benefit to the people, not only of this part of the State, but to the great commonwealth of the State.

Trusting that your honorable body will enact such laws as will meet the emergency, your petitioners will ever pray.

W. W. BEDFORD,
A. E. BENDING,
F. X. McATEE,
J. H. MITCHELL,
W. M. ROBERTSON,
A. L. HENDRICKS,
A. BLASKE,
G. S. HENDERSON,
LOUIS COHEN,
A. J. MILLICAN,
M. L. WEBBER,
D. D. WELCH,
S. W. PEPPERDINE,
A. SMITH,
GEO. H. KNIGHT,
JAS. C. LEWIS,
R. W. MARPLE,
J. W. MALONE,
S. MORRISON,
J. W. BARBER,
G. F. CLAUSEN,
HARRY MAGNISS,
A. H. COOK,
R. C. HARPER,
N. C. FANINGTON,
CHAS. MILLER,
J. B. ROSS,
HENRY E. BEDFORD,
J. M. BEDFORD,
WADE PARKS,
E. B. HALL,
JOHN GREEN,
MARK SMITH,
ANDY SMITH,
ISA HURLBERT,
D. SONGMIRE,
F. Z. PALMER,
SIMEON COEN,
WM. COEN,
A. MORRIS,
ASA HOLLINBEAK,
JOHN HOLLINBEAK,
S. MAGUIRE,
JOHN GREEN,
W. H. HALLANSHEUK,
A. TARTAR,
S. PENINGTON,
PETER HENSEN,
B. Q. HOLLINBEAK,
C. JOHNSON,
N. CLARK,
J. B. POST,
A. SPEGLEE,
N. N. PARKER,
IKE VESTAL,
A. DEWITT,
ROBERT PERRY,
D. R. BROWNELL,

J. W. McCOY,
JOHN G. BALLEWEY,
J. H. JAMES,
JOSEPH WILSON,
C. P. WILLIS,
C. WHITMAN,
C. A. McCASH, M. D.,
L. S. BARNES,
J. S. SWEET,
H. J. SCHROEDER,
JNO. D. CRITTENDEN,
J. MADDEN,
S. C. MOVERS,
C. H. CUTTER,
J. H. BEECHER,
J. B. BLAKE,
H. F. HALL, M. D.,
AUSTIN MODIE,
A. G. McDOWELL,
JOHN DEPP,
OLIVER McDOWELL,
W. C. LAIRD,
G. LAPWINT,
S. A. WILSON,
C. A. WILLIS,
H. SCHMINCK,
E. W. GROVES,
J. M. CHACE,
A. J. STRIPLING,
THURSTON HILL,
C. W. RICE,
JOHN FIOCK,
S. A. ROSEBERRY,
I. H. JONES,
C. A. BAFINGER,
HUGH MONTGOMERY,
J. M. WALKER,
JOSEPH HALE,
C. E. TITUS,
L. M. SAIN,
H. KELLEY,
F. JONES,
JOHN L. CHACE,
PETER EILER,
J. W. GLASCOCK,
J. B. McCLELLAN,
J. E. GANSING,
DE WINTER,
J. H. WISEHEART,
J. F. SWAN,
MELLOR COMBS,
C. WARNER,
M. P. ROSE,
J. N. COX,
J. A. WINTER,
J. W. SOUTHARD,
W. G. STEARNS,
J. T. GIBBINS,
JOHN M. RALLS,
JOE GUMMER,
J. QUINN,
J. T. SHABERT,
L. G. BROWNELL,
J. A. CASNER,
I. W. BARRETT,
MILTON WATSON,
J. KENNEDY,
J. H. WHITTLEY,
O. H. WHITE,
DR. PHILLIBO,
T. H. McBRIDE,
WILLIAM GOWIDY,
J. F. CURTIS,
HERBERT A. S. COOLEY,
F. M. HOLABIRD,
A. W. COOK,
C. F. EARLE,
S. H. PAULK,
M. M. DOUGHERTY,
ARAD WAY,
WM. PARKER,
H. WAY,
J. G. HENSLEY,
A. BABCOCK,
F. M. CRABB,
WM. CLARK,
WM. PACKWOOD,
C. BABCOCK,
W. R. SCHOOLER,
THOS. SUMMERS,
EDWARD HARRIS,
STEPHEN HOLCOMB,
S. C. BEARD,
JOHN ANDERSON,
R. P. COURTRIGHT,
J. M. STRESHLY,
E. EZENHOUSER,
A. F. LINCOLN,
D. C. BROWNELL,
L. C. WILSON,
H. STAINBROOK,
C. F. MIERS,
JOHN KIMBLELIN,
L. S. CARNICIO,
G. W. ELLIOTT,
A. S. COOLEY,
T. W. SOUTHARD,
W. H. KELLY,
MARTIN MEGHORN,
GEORGE M. CHENY,

THOS. Z. DRAIS,
G. W. OLIVER,
E. GABY,
M. McCRAY,
DANIEL HANEY,
RALPH ROBERTS,
WM. STRAUB.
H. PAINTER,
C. S. DEWEY,
J. P. KIMBRELL,
E. FLORIN,
FRED. FLORIN,
LOUIS FLORIN,
ED. W. LANSING,
J. S. KENTNER,
FRANK DONELSON,
C. H. MANNING,
T. W. SAMPSON,
G. P. McFADEN,
J. C. DARDEN,
D. MUREKINS,
ROBT. COLBORN,
C. T. WISE,
L. MARKS,
JOHN McARTHUR,
E. G. CAMPLIN,
O. R. HILDRETH,
T. H. VESTAL,
E. E. ANGLIN,
C. PENROSE,
C. YOUNG,
TOM YOUNG,
J. VESTAL,
T. McWILLIAMS,
J. B. GATES,
R. F. GATES,
JAMES McWILLIAMS,
WM. HARTLEY,
GEORGE WALSTON,
LEVI BROWN,
D. TARTER,
J. W. SUNNERS,
W. D. NASH,
JOHN W. ROGERS,
J. WALSH,
A. COATE,
E. DOWELL,
F. MEYER,
F. L. RALLS,
N. BIEBER,
GEORGE EARLE,
WM. BABCOCK,
JAMES FINLEY,
NOAH KNOX,
ISAAC GINN,
J. D. BIERD,
A. RALLS,
J. KILBY,
JOHN ARNETT,
J. H. PACKWOOD,
W. B. WALL,
GEORGE H. BEAN,
M. A. CARMECHIAL,
LEWIS POWERS,
JOHN T. HOLABIRD,
W. S. MONTGOMERY,
CHAS. A. MAYHEW,
CHARLES HOWELL,
H. RUNES,
JACOB HOCKMAN,
W. F. WARE,
ROBT. HARDIN,
P. PEDRIEN,
W. H. RONEY,
J. H. BIDWELL,
H. J. McGHAN,
P. C. ROBERTSON,
LEWIS KENYON,
F. H. KENYON,
R. H. LYON,
JOHN PURROTT,
J. C. McCOWN.

REPORT

OF THE

COMMITTEE ON STATE HOSPITALS,

RELATIVE TO

INSANE ASYLUMS.

REPORT.

MR. SPEAKER: Your Committee on State Hospitals herewith submit the following report on Insane Asylums:

In accordance with our duties we visited the Insane Asylums at Napa and Stockton. We found both well managed, and conducted with economy. From all the information we have obtained, there are but two institutions of like nature in the United States that are conducted with more economy and less expense. The Asylums of Stockton and Napa are under the respective management of Doctors Shurtleff and Wilkins, both of whom fully understand their duties, and show by their management that the interests of the State and the welfare of the inmates are duly considered.

On July thirtieth, eighteen hundred and seventy-nine, the total number of patients in the Stockton Asylum was one thousand one hundred and twenty-seven, and of Napa, seven hundred and fourteen. The number of patients is decreasing at Stockton, and increasing at Napa at the rate of thirteen and one third per month. The total number of patients received at Stockton Asylum for the past year was one hundred and six, while at Napa it was six hundred and fifteen.

The managers of the Napa Asylum have been forced to fit up and furnish additional wards to meet these steadily increasing emergencies. An item of ten thousand dollars embraced in the Steward's account in the last report of the Napa Asylum, was for fitting up new wards, as above mentioned, and should be deducted from the cost of maintenance, as the Superintendent has correctly done.

In the Stockton Asylum, or any other institution of long standing, it goes to the maintenance account. The climate at Stockton is much warmer than at Napa, and the cost of fuel less. The Napa Asylum expended in March, eighteen hundred and seventy-nine, the sum of one thousand eight hundred dollars for fuel, and one thousand seven hundred dollars for each month during the winter season. At Stockton the Superintendent and two assistant physicians live outside the building, while at Napa they reside in the Asylum.

In eighteen hundred and seventy-seven the Managers of the Napa Asylum fitted up wards for the accommodation of one hundred and thirty-three patients; and in eighteen hundred and seventy-eight wards were fitted up for one hundred and seventy-six patients; the costs of which improvements were included in the Steward's report for those fiscal years respectively. Deducting the item of ten thousand dollars from the Steward's account, as above mentioned, it makes the cost per capita, for the last fiscal year, forty-four and seven twelfth cents per day. The cost for keeping a thousand patients is less than the cost of maintaining a smaller number, and we find that as the numbers have increased at Napa, there has been a correspond-

ing decrease in the cost per capita. In eighteen hundred and seventy-six and eighteen hundred and seventy-seven the cost at Napa was fifty-five cents per day, while for eighteen hundred and seventy-eight and eighteen hundred and seventy-nine it was forty-four and seven twelfth cents per capita per day.

We find little or no difference in the economical management of the two asylums, and deem the management of each worthy of commendation. Doctor Wilkins states that if the entire asylum was fitted up it would accommodate two hundred additional patients, and if the ratio of increase still continues, at the end of the next fiscal year there will be nine hundred and fifty-six patients in the Napa Asylum. That wards be fitted up to meet these steadily increasing numbers, we deem an imperative necessity. As a matter of strict economy, the windows of the basement should be glazed, as it will curtail the expense of heating; the elevator should be made fire-proof; and some improvements are necessary for the grounds. Some repairs and corrections should be made to the buildings; the attics should be completed; faults in sewerage should be corrected, and partitions should be made in the rooms of the attendants. We are informed by the Superintendent, that all these improvements can be made with an appropriation of thirty-five thousand dollars. We therefore recommend that the sum of thirty-five thousand dollars be so appropriated. We found the male departments at Stockton in a crowded condition, and much repairing necessary.

The Superintendent, Dr. Shurtleff, assures us that it is imperative. We have fully satisfied ourselves of the fact that it is a necessity, and have also considered the question of the amount that is required, and we think that there should be not less than one hundred thousand dollars so set apart, and we hereby recommend that said sum be so appropriated.

We deem it unnecessary to append tables, compiled from the published reports of these asylums, as the reports themselves are full and explicit, and the same can be had at any time, by persons desiring such information, on application to the Superintendent or to the Secretary of State.

All of which is respectfully submitted.

BRUSIE, Chairman.
MATHEWS,
HARRIS,
DURHAM,
COOK,
Assembly Committee.

PETITION OF STATE BOARD OF HEALTH

RELATIVE TO

A STATE HOSPITAL FOR CONSUMPTIVES,

AND

Senate Concurrent Resolution No. 25 relative to said Petition.

INTRODUCED BY MR. HITTELL, FEBRUARY 18. REFERRED TO COMMITTEE ON HOSPITALS.

PETITION.

To the Honorable the Legislature of the State of California:

At a regular meeting of the State Medical Society held in the City of San Francisco, April 16th, 1879, the undersigned were appointed a committee to petition the Legislature to take action looking to the establishment of a "State Hospital for Consumptives."

California, as a State, occupies a somewhat peculiar and exceptional position. It invites immigration on account of its mineral resources, its vast agricultural advantages, the adaptation of its soil and climate to the cultivation, not only of the ordinary productions of the farm, but, in many sections, of tropical and semi-tropical fruits, while, at the same time, it has held out inducements to settlement based upon sanitary advantages of which few of the other States can boast. Hence, it has become the resort not only of the young and vigorous and those seeking to engage in active industrial or business pursuits, but by the weak and dependent, by invalids seeking to avail themselves of the benefits, real or imaginary, which the climate affords. A very large proportion of this latter class are sufferers from chronic pulmonary complaints, victims of consumption, whose coming has been encouraged and hastened by the laudatory and oftentimes injudicious accounts given of the special advantages of the climate by interested land owners or enthusiastic travelers. That some derive benefit from the change, and are apparently restored to health, is true; but the misfortune is that very many whose strength is already far spent, and who are sufferers from the advancement and generally incurable stages of disease, come only to reap disappointment and to die among strangers. It is, to a large extent, from this class, unable to work, without means or friends, that our hospitals are filled. How many such find their way to California, the public, it is believed, have but a faint conception.

In eleven hospitals reporting to the State Board of Health for 1878, there were, in a total of 1,884 patients admitted, 127 cases of consumption, or nearly 7 per cent. In San Francisco alone—1878-9—out of a total of admissions amounting to 3,174 patients, 245 were due to consumption, or nearly 8 per cent.; and John S. Hittell, Esq., in remarks upon this subject in its relation to San Francisco, has shown that, as a rule, "about three hundred consumptives, two hundred of them from other counties, are admitted annually into the County Hospital, and the expense to San Francisco of these two hundred phthisical patients from other parts of the State is perhaps $13,000 a year, enough to provide for six hundred patients of other classes, since the consumptives live longer and cost more on the average than the others."

The history of many of these invalids antecedent to admission to the hospital, we are commonly unable to trace, yet sufficient is known

to warrant their classification with those to whom the remarks above made apply.

The question is, not so much as to the propriety of imposing upon a few counties the expense of caring for and supporting, often for many months, this increasing class of invalids, or of taxing a few for what, in the opinion of many citizens, should, of right, be made a State charge. The argument upon which we rely is of a higher and more honorable character; it is above all considerations of dollars and cents; it looks only to the welfare of these unfortunate invalids; it is strictly a question of philanthropy—essentially humanitarian in its nature. It is to benefit the sick and suffering; to save life, when this is possible; to place the invalid under such conditions of locality, climate, regimen, and general management, as shall be most favorable to improvement in health, and, possibly, to ultimate recovery. Such conditions are seldom found in our county hospitals. Observation has shown that certain sections of the State are more favorable to the consumptive than others; that certain conditions of climate, as soil, elevation, temperature, and humidity—that the adoption of certain habits and modes of living are, it might almost be said, essential to success in the treatment of consumption. Many of our county hospitals are not properly located to supply these advantages; some of the conditions just mentioned are wanting; some of them are unsuitably constructed; and not many have accommodations for the class of invalids under consideration, without doing injustice to others the proper subjects of their care. It is only in a State institution, eligibly located, suitably equipped, specially constructed, and adapted to the hygienic treatment of consumption, that the full benefit of our climate may be demonstrated. It is not impossible that such a demonstration, besides fulfilling all the obligations which the spirit of philanthropy imposes, may, by its favorable result, be the means of attracting population, and thus amply repaying the cost expended. Under the existing circumstances, the State is losing in sanitary reputation. Should the measure recommended be adopted, it cannot fail to gain.

Doubtless, a considerable proportion of those who now find their way into our county hospitals and die there, would, if a proper place were provided for treatment, recover their health and become useful and profitable citizens. Many, not entirely destitute, would avail themselves of the advantages afforded by such an institution; many others, not able to perform hard labor, could be profitably employed in those out-door exercises which would form an essential part of its hygienic management; and there is no reasonable doubt that it would eventually be almost, if not quite, self-sustaining.

Being fully persuaded of the expediency of the proposition embodied in this petition, and of the benefits which would result therefrom, not only to the unfortunate invalid, but to the reputation of the State, the undersigned respectfully submit the subject to the consideration of the Legislature.

F. W. HATCH,
W. AYER,
W. P. GIBBONS.
Committee.

SACRAMENTO, February, 1880.

REPORT OF THE TRUSTEES

OF THE

CALIFORNIA STATE NORMAL SCHOOL.

REPORT.

SAN JOSE, CALIFORNIA, January 1st, 1880.

To his Excellency, Geo. C. Perkins, Governor of the State of California:

The Trustees of the California State Normal School beg leave respectfully to submit the following report of the institution under their charge. The report includes the full transactions of the thirtieth fiscal year, and the transaetions of the thirty-first fiscal year to December 31st, 1879.

During the thirtieth fiscal year, the whole number of pupils taught, (exclusive of the Training School) was five hundred and forty-eight, and the average attendance for the entire year was three hundred and ninety-one.

Two classes were graduated, one with full diplomas, numbering forty-four, and one with elementary diplomas, numbering forty-three.

For a more detailed statement of the school work for the thirtieth fiscal year, we respectfully refer your Excellency to the catalogue herewith submitted, and to the report of the Principal therein contained.

The average attendance for the first half of the thirty-first fiscal year has been three hundred and twenty-five. The school will be somewhat larger during the coming term.

On the 19th of January, two were graduated with full diplomas, and nineteen with elementary diplomas. At this time, when there is a growing demand for more thoroughly trained teachers, we are sure that the graduates of the school will contribute much toward supplying this demand, as also toward increasing the efficiency of our public schools. We may add that nearly all the graduates are at work, and that, in the main, their work is in the highest degree satisfactory.

In judging of the usefulness of the school, it must also be remembered that a large number of our under-graduates obtaining certificates at the county examinations become teachers, and we confidently hope teach better from the instruction received in the Normal School.

In addition to the Normal School proper, we have, as required by law, maintained an efficient Training School, in which pupils before graduating are required to observe and practice teaching, until they show themselves qualified to teach well. The Training School consists of from eighty to one hundred pupils from the City of San Jose,

whose parents are willing to pay a liberal tuition fee for the superior advantages they enjoy.

We have also found it advisable to maintain a Preparatory Department, where those who are not sufficiently advanced to enter the Normal Classes may fit themselves. Many of these come from a distance, and it seemed hardly just to send them home, particularly as the Department is nearly self-sustaining. In this, also, a tuition fee is required.

For a statement of the receipts and expenditures of the tuition moneys, and of the other funds placed at our disposal, we respectfully refer to the financial report hereto appended.

As the grounds owned by the State, surrounding the Normal School, were in a disgraceful condition, and as the last Legislature with singular unanimity, after receiving the reports of the legislative visiting committees, passed a bill making a liberal appropriation to put the grounds in order (which bill failed to become a law), we have felt justified in using the tuition moneys, paid largely by citizens of San José, in improving these grounds. The money has been economically expended, the amount paid for filling and grading not reaching sixty per cent. of the estimates made by the experts accompanying the legislative committees. About five and one-half acres have been graded and fenced, and a part of it planted to trees and shrubs. We confidently expect that the present Legislature will allow us enough to complete the work begun, so that the surroundings of the school may comport with the building, as well as be made more comfortable, healthful, and pleasant to those who come here to prepare for the work of teaching.

A part of the appropriation for the thirty-first fiscal year, not being necessary for the efficiency of the school, will be, at the end of the year, returned to the State treasury.

Our estimates for current expenses the coming year have been carefully made, and every dollar asked will be needed, to have the work done as it should be in the school.

They are as follows:

Salaries	$28,000
Insurance	625
Stationery	600
Fuel	500
Books and additional apparatus	500
Chemicals	100
Incidentals, gas postage, etc.	675
	$31,000
Less tuition (say)	3,000
Amount of annual appropriation required	$28,000

Some repairs will be necessary on the building, with additional cases for the library and cabinet, and to fence properly and put in good condition the remainder of the twenty-eight acres in the Normal School Square, will require the sum of $25,000.

In conclusion, we submit the financial report of the school, feeling assured that when examined, and compared with the work done, it will be found that the moneys have been judiciously and economically expended, and that the Normal School returns to the public schools of the State far more than it costs to maintain it.

FINANCIAL REPORT FOR THE THIRTIETH FISCAL YEAR.

July 1, 1878—By appropriation		$33,300 00
To paid salaries of teachers, janitor, and librarian	$28,840 00	
To paid bills for stationery	624 65	
To paid insurance, $50,000 @ 1¼ per cent.	625 00	
To paid fuel	502 46	
To paid apparatus and furniture	1,034 09	
To paid books for library	211 38	
To paid repairs	611 39	
To paid chemicals	54 90	
To paid sundries, including gas, water, janitor's supplies, postage, and commencement expenses	796 13	
		$33,300 00

TUITION ACCOUNT FOR THE THIRTIETH FISCAL YEAR.

July 1, 1878—By amount on hand		$536 66
By amount received during the year		3,952 89
To paid salary, one month, assistant in preparatory department	$80 00	
To paid fuel (kindling wood)	17 28	
To paid furniture	151 25	
To paid extra janitor labor	24 00	
To paid repairs	350 85	
To paid surveying and leveling for filling	66 25	
To paid filling, earth and gravel	2,534 83	
To paid fencing, and painting same	1,026 83	
To paid sundries	38 75	
To balance on hand	199 51	
		$4,489 55
July 1, 1879—Balance on hand	$199 51	

FINANCIAL REPORT FOR THE THIRTY-FIRST FISCAL YEAR, TO DECEMBER 30, 1879.

July 1, 1879—By amount of appropriation		$33,300 00
To paid insurance, $50,000, @ 1¼ per cent.	$625 00	
To paid salaries, five months—½ year	13,469 00	
To paid fuel	510 38	
To paid stationery	148 53	
To paid repairs	277 51	
To paid furniture	132 40	
To paid books for library	50 96	
To paid chemicals	50 85	
To paid sundries, gas, janitor's supplies, etc.	226 29	
To balance	17,809 08	
		$33,300 00
January 1, 1880—Balance on hand	$17,809 08	

TUITION ACCOUNT FOR THE THIRTY-FIRST FISCAL YEAR, TO DECEMBER 31, 1879.

July 1, 1879—By amount on hand		$199 51
By amount received to December 31, 1879		1,754 15
To paid P. J. Kelly for filling square	$1,440 00	
To paid W. A. Carpenter, gravel	25 00	
To paid rent of piano	62 50	
To paid bill of Auzerais & Pomeroy	52 56	
To balance on hand	373 60	
		$1,953 66
December 31, 1879—Balance on hand	$373 60	

We beg leave to subscribe ourselves, very respectfully, your obedient servants.

Per order of the Trustees of the State Normal School.

CHAS. H. ALLEN, Secretary.

REPORT

OF THE

Committee on Public Buildings and Grounds,

RELATING TO

STATE INSTITUTIONS.

REPORT.

Mr. Speaker: In compliance with the resolution passed by the Assembly January twenty-sixth, eighteen hundred and eighty, your Committee on Public Buildings and Grounds proceeded to visit the various buildings and grounds of the State, with the exception of those devoted to prison purposes; and, after a critical examination of the same, as the result of their investigations, beg leave to make the following report:

At the last session of the Legislature large sums of money were voted which were intended to be used in the erection of a series of new buildings, and, where necessary, the repair of old ones, and also for the improvement and beautifying of the public grounds at various localities; but the Governor refusing to give his sanction to the same, the appropriation bill did not become a law. For this reason no new structures have been erected in any locality, and the grounds in most places remain in the same condition that they were two years ago, thus explaining the necessity for seemingly large appropriations at this session.

THE INSANE ASYLUM AT STOCKTON.

The committee met at the asylum on the afternoon of January twenty-seventh, and immediately proceeded to make a careful examination of the entire premises.

Your committee found the new buildings occupied by the female patients to be a model of its kind, admirably adapted for the purpose for which it was built, neat and clean, and in every respect a fine, commodious, and comfortable building—a credit to the State and to the officers having the management of it.

Your committee then examined the Second Ward, where the most violent patients are kept. Here we found sixty-six patients crowded together in a low, one-story brick building, the inside width of which they found by actual measurement to be twenty-nine and one half feet, and the inside length to be one hundred and fifty and one half feet—a low, damp, ill-lighted, dark, loathsome place, and so constructed that it is impossible to properly heat the house.

This building was built in the year eighteen hundred and fifty-eight, and was constructed of soft brick, which, in the winter time, absorbs the moisture, making it extremely damp and unhealthy. The floor is made of asphaltum, is very uneven, and considerably below the level of the courtyard outside.

It is the opinion of your committee that this building is below any standard which we consider necessary for the proper receptacle of human beings, even though they may be insane. In this ward, at least one third of the patients sleep upon the floor of the corridor, for want of room to put them elsewhere.

In the Tenth Ward, the lower building is a counterpart of the one just described, with the exception that it is not so long, being only seventy-six feet in length.

In what is called the Cottage Ward, your committee found a large wooden building, which was put up as a temporary structure to accommodate the pressing needs of the institution. It is warm and airy enough, and although somewhat overcrowed, still, in comparison with the low brick buildings, is a model structure. Your committee are of the opinion, however, that it is extremely unsafe to keep the insane in a wooden building, as, in case of fire, it would be next to impossible to rescue all of the inmates. All buildings erected should be constructed of either brick or stone, and they to, in such a manner that there be as little combustible material in the building as possible.

A design has been made by the doctors for the erection of a new substantial brick building, the cost of which will be in the neighborhood of eighty-five thousand dollars, which will accommodate, by having large dormitories and dining rooms, instead of single rooms, in the neighborhood of three hundred patients.

This will relieve the Asylum of its pressing necessities, so that the officers will be able to remove the patients from the mad and imbecile wards, and also from the Cottage Ward.

The various courtyards and walks need graveling, as, during the winter months, they become unfit for the patients to walk and exercise upon.

We would recommend that the new building be so constructed that it can be added to should the necessity for it ever arise.

In conclusion, your committee would recommend an appropriation of one hundred thousand dollars, which we consider sufficient to erect a new ward, gravel the walk, erect a new house for the engine, and do some necessary painting.

Your committee, in recommending the above amount, feel that they have asked for the lowest amount which the necessities of the Asylum requires.

THE STATE NORMAL SCHOOL.

Since the last session of the Legislature the only improvements made to the Normal School property has been the filling in, grading, and planting the five and a half acre plat next the building. Your committee found a large, commodious, and well appointed building, but sadly needing repairs—the floors and entrances being badly worn. The attention of your committee was called to the fact that the chimney-flues on the top of the building were in a bad condition, and that new ones were needed.

Since visiting this institution, it has officially come to the knowledge of your committee that the magnificent building occupied by the school has been entirely destroyed by fire. As to the manner in which it caught on fire, your committee have had no official information.

Your committee recognizing the fact that Normal School education is of great benefit to the educational interests of the State, would most respectfully recommend an appropriation be made as early as possible for the erection of a building suitable for the needs of the school. Your committee think that, after the lesson afforded by the loss of the last building by fire, it would be wise to construct the new

building of brick or stone in a substantial manner, and having sufficient capacity to properly accommodate five hundred persons. The building should contain, in our opinion, about twenty class-rooms of the dimensions of twenty by sixty feet; eight small practice-rooms; a laboratory room and store room connected with it; one Natural History room; one room for the museum; one library room; one large office for use of Trustees; one reception room, and a large assembly hall. We also deem it necessary that there should be built a first-class furnace for heating the building, so arranged that there be no danger from fire, as we consider this a safer, cheaper, and better way to heat a large building than by the old fashioned plan of using stoves and fireplaces. We think a suitable furnace can be put up for about fifteen thousand dollars.

The Normal building which has just burned down was a very large and finely ornamented building. It was somewhat larger than the present needs of the institution require, and more ornamental. Your committee would therefore recommend that an appropriation of one hundred and fifty thousand dollars be made for the erection of a new Normal building; which sum we think, will build it with the necessary furnace attached to it, and that it be built of brick.

The tract of land donated by the City of San José to the State for Normal School purposes, is a very large and valuable one, consisting of twenty-eight and a half acres, lying in the very heart of the city.

This property should be well taken care of, by planting trees and erecting a suitable fence to surround the inclosure, doing some necessary grading, etc., but owing to the fact of the necessity for a large appropriation for the erection of a new building, your committee do not recommend any appropriation this year for that purpose.

THE NAPA STATE ASYLUM FOR THE INSANE.

This institution is pleasantly situated about one mile from the town of Napa. The Asylum is one of the finest buildings of the kind in the world, and has every convenience for the proper care and comfort of the patients that modern invention could devise.

A vast sum of money has been uselessly spent in the ornamentation of the exterior of the building. In fact, more money has been laid out in putting up lofty towers, and in grand entrance halls, and stairways, than in all the departments allotted to the patients. This building has cost the State something over one million three hundred thousand dollars, or about one thousand five hundred dollars for the accommodation of each patient, and yet the building is not entirely finished. It has cost more according to the number of patients accommodated than any similar institution in the United States.

There are many parts of the Asylum that should be finished, and by so doing, room will be obtained for from two hundred and fifty to three hundred more patients.

There are four large attics, situated over the store rooms and laundry, and also over the extreme wings of the Asylum building proper, that can be fitted up at comparatively small cost, and make room for about one hundred and fifty additional patients. There are also four large attendants' rooms that can be fitted up and partitioned off into wards, and be used for dormitories.

Your committee think that, when the increasing wants of the Asylum require it, the officers' quarters can be fitted up at a small cost to the State, and room made for ninety or one hundred additional patients. But by so doing, it will be necessary to build houses for the President, physician, and one of the attendant physicians. There should be partitions put in wards A, B, Y, and Z, as the most violent class of patients are kept there, and these wards are too large for that purpose. There are defects in the construction of the various bath-rooms and water-closets that should be attended to. Iron gratings or guards should be put up over a large number of windows in the upper stories, so that when they are raised in order to secure the necessary ventilation, the violent patients cannot jump out on the pavement below. Your committee would recommend that an appropriation of twenty-five thousand dollars be made, to be used in fitting up the various attics before mentioned, as we think that by so doing the pressing necessities of the Asylum will be relieved.

There are about thirty acres of tule land that should be reclaimed, as upon this land vegetables could be raised to supply in a great measure the Asylum. The large clock weight, situated in the central tower, is in danger of falling, in which event considerable damage will be done, and should be properly secured.

The sewer should be extended down to tide water, and thus relieve the Asylum from the stench which now prevails there when the wind blows from the end of the sewer, towards the Asylum.

We think that a fence, of about two miles in length, should be built of rough material, to replace the old one, which will entail an expense of about fifteen hundred dollars.

There is pressing need for a fire-proof vault in which to keep the records of the institution, and any valuable articles that may be taken from the patients upon their entering the Asylum.

There should also be constructed five elevators and two clothes shafts, at a probable cost of two hundred dollars each.

The walls and floors in various parts of the building should be painted and some necessary repairs made.

Your committee therefore recommend that an appropriation of ten thousand dollars be made for the last named necessities, in addition to the twenty-five thousand dollars recommended for fitting up the interior of the Asylum.

There are many other matters that need attention, viz: Two new infirmaries should be built; a large reservoir constructed, which, no doubt, would add greatly to the sanitary condition of the Asylum.

Your committee feel, however, although the addition of these last named things would be of great benefit to the Asylum, yet, owing to the fact of there being absolute necessity for large appropriations at the Stockton Asylum, and for the erection of a new Normal School building at San José, that we cannot recommend any greater sum than thirty-five thousand dollars, which sum we think can be judiciously expended as above designated.

There is a tract of land back of the Asylum buildings which we consider should be bought by the State. Being contiguous to the Asylum tract the patients are now in the habit of roaming over the land, which is a great annoyance to the owner. Reservoirs can be constructed upon the land, and from them the Asylum can be supplied with water.

There is pressing need of a graveyard in some place retired from the view of the patients, and such a spot can be easily found upon what is called the Coombs property. Mr. Coombs offers some four hundred acres, being the land above described, to the State for fifteen thousand dollars; and your committee are of the opinion that it would be advisable to purchase the land.

THE DEAF AND DUMB AND BLIND ASYLUM.

The Legislature, at its last session, made an appropriation for this institution, but it, in common with a number of other appropriations, failed to receive the signature of the Governor.

This institution has several fine buildings, the Trustees having adopted what is known as the segregate system, and one which your committee finds admirably adapted for carrying out the purposes for which the Asylum was created. The buildings have been constructed with a view to economizing space, and with as little combustible material in them as was practicable, so that it would seem almost impossible to burn them down. The segregate system has the advantage over the congregate system in this, that there can always be more buildings added to the group, and in case of any of the children being attacked by infectious disease, it will be much easier to control and keep it within bounds; and should any one building catch on fire, but one house will be destroyed, and the institution will not be left homeless as it was several years ago.

All of the various buildings, including the homes, laundry, dining-room, and kitchen, gave evidence of being well taken care of, and under a skillful and conscientious management. Your committee recognize the fact that the building called the workshop should revert to the purpose for which it was erected, viz.: as a place in which to instruct the children in a mechanical education, it being now used for recitation rooms and dormitories. The mechanical department is one of the most important parts of the institution, as in it the children are taught the various avocations and trades upon which the pupils, in after years, will be compelled to rely for their own maintenance; and it should be fitted up with proper tools, apparatus, and machinery for the teachers to successfully accomplish this part of the work. The foundation of this workshop building is of wood, and very rotten and unsafe to put machinery into in its present condition. There should be placed under it either a brick or wooden foundation.

Your committee would recommend an appropriation of seventy-five thousand dollars to be expended in building a new house, constructing a new foundation for the workshop, putting in some machinery, buying necessary tools and implements, and repairing the dining-room, etc. Your committee recognize the fact that there should be constructed, at some future time, a reservoir, for the better supplying the Asylum with water for house and garden purposes; and also that there should be erected an educational building, but we think that the institution has no pressing need for them at present. The grounds belonging to the Asylum (there being about fifty acres under cultivation) are kept in admirable condition, and with but very little expense to the State, as, with the exception of one gardener to superintend, the work is all done by the male pupils of the

Asylum, every boy having to work some time during each day in the garden or fields.

The new building, which we recommend an appropriation for, should be built expressly for the female department, as the houses already erected were intended ultimately to be used by the male students. Your committee would earnestly recommend that the segregate system already adopted be carried out as far as practicable, and that the money appropriated be spent in building a house similar to those already constructed, as we think that they have been erected upon an economical plan, and that all of the structures taken together form a harmonious and beautiful whole, a credit to the State, and finely adapted to the purpose for which they were constructed.

JOINT REPORT

OF THE

Hospital Committees of the Senate and Assembly,

ON

ORPHAN ASYLUMS.

REPORT.

Mr. President: Your Committee on Hospitals, in conjunction with the Hospital Committee of the Assembly, herewith submit the following report on Orphan Asylums:

In accordance with resolution of instruction, we have visited, with the exception of two, all the Asylums receiving aid from the State; we have caused a thorough examination to be made of all their books and accounts, and have obtained all the information possible as to their condition and management. Almost without exception we have found them clean, well conducted, and well managed. Strict regard for sanitary conditions, plain, wholesome, and generous diet, systematic education and recreation, are all evidenced by the appearance of the inmates. In the institutions we visited, medical assistance is seldom required, the medical bills are small, and deaths are of rare occurrence. The moral and intellectual training, coupled with the strict discipline maintained, encourage us in the hope that these wards of the public will eventually become useful citizens. After a thorough examination of the Asylums already established, and a careful consideration of the subject, we are satisfied that a judicious system of State appropriations, apart from any duty that charity demands, will eventually amply repay the State for all expenditures by reducing the number that would otherwise naturally grow up as a part of our ignorant and criminally disposed population.

This question of providing for the homeless has already become one of much importance to the State.

"Political economists have long since recognized the fact that juvenile destitution is a prolific source of depravity, and, unless relieved, must ultimately swell the criminal records and prove a heavy tax upon the material prosperity and resources of the State."—Report of Ladies' Relief Society, San Francisco.

In view of these facts, in connection with the Hospital Committee of the Assembly, we have compiled, and herewith append, statistics, as full and complete as the present imperfect system of book-keeping in these institutions will permit.

It will be seen from these tables that the State contributed to the support of 1,992 orphan and half orphan children the past year the sum of $135,350 98. Estimates for the coming year are not less than $160,000. As the State only appropriates for the support of children under fourteen years of age, and as many Asylums maintained a number of children over that age, together with a large number of little waifs, and a few aged and infirm females, the State appropriation has not been sufficient, of itself, to maintain them, and we find they received from other sources, in 1879, $150,337 36.

We are informed by the managers that no discrimination is made in admitting children into any of these Asylums, because of the religion of the parents, though the Asylums are generally under denominational auspices and control. There are sixteen Asylums receiving State aid.

Ten of these are under the management of the Catholic Church. They contain 1,326 children receiving aid, and they received, in 1879, $93,694 83.

The Pacific Hebrew Orphan Asylum of San Francisco contains none but Hebrew children. In 1879 it received, for forty children, the sum of $3,652 50.

The Good Templars' Home for Orphans contains ninety-four children, and received, for 1879, $6,604 55.

The Ladies' Protection and Relief Society of San Francisco, the Protestant Orphan Asylum of San Francisco, the Ladies' Relief Society of Oakland, and the Protestant Orphan Asylum of Sacramento, supporting an average of 536 children, received $31,399.

The small amount paid to these Asylums by the State is owing to the fact that the Ladies' Protection and Relief Societies of San Francisco and Oakland have supported an average of one hundred abandoned and destitute children for whom they received no aid from the State. The Ladies' Relief Society of Oakland has drawn $500 per annum, with no pro rata for orphans until the last quarter of the thirtieth fiscal year. Although as truly an Orphan Asylum as any, still, relying upon their own exertions, and the charitable donations from the citizens of Oakland, until the business depression of the past year they have asked no further aid from the State.

These relief societies deserve especial commendation.

We herewith append an exhibit from the various Orphan Asylums for the twenty-seventh and twenty-eighth fiscal years, showing their total receipts from all sources, the disbursements of the same, and the purposes for which expended; also, the amount necessary for maintaining an orphan in the necessaries of life, both including and excluding salaries. We also append an abstract from the reports of the Ladies' Relief Society of San Francisco and the San Rafael Catholic Orphan Asylum for the years 1878 and 1879. These institutions may be taken as representative Asylums. The first returns the actual cost of maintaining a child in the necessaries of life at $79 33 for 1878, and at $73 05 for 1879. The San Rafael Asylum shows a cost of $94 10 per annum. There are, however, items to the amount of $9,500 included in the latter that are not found in the former. Deducting these, it reduces the San Rafael estimate to $67 per annum.

The question, however, is not upon how little an orphan can actually subsist, but the least amount that will enable an Asylum to give maintenance to a child, with due consideration for its mental, moral, and physical development.

ROWELL, Chairman.
ANDERSON,
LAMPSON,
GORMAN,
HUDSON,
Senate Committee.

BRUSIE, Chairman.
DURHAM,
HARRIS,
COOK,
MATHEWS,
Assembly Committee.

ABSTRACT.

From the statements of the various orphan asylums, for the twenty-eighth fiscal year.

Name of Asylum.	Average number of orphans during the year	Average number of half orphans during the year	Moneys received from the State	Receipts, in value, from all sources	Total receipts	Amounts expended in the necessaries of life for orphans	Amounts expended, exclusive of necessaries of life, for orphans, including salaries and other expenses	Total expenditures	Cost of each orphan per day, in necessaries of life—cents	Cost to each orphan in salaries and other expenses—cents	Total cost per day—cents
San Francisco Roman Catholic Female Orphan Asylum	86	136	$16,478 64	$10,742 40	$27,221 64	$15,535 45	$8,872 65	$24,408 10	19.15	10.94	30.09
St. Joseph's Infant Orphan Asylum, San Francisco	30	130	10,303 11	6,917 96	17,221 07	12,543 90	4,667 17	17,221 07	21.43	08.00	29.43
San Francisco Protestant O. A.	47	147	13,647 55	11,608 58	25,256 13	12,345 13	12,095 54	24,440 67	17.38	17.08	34.46
Sacramento Protestant O. A.	10	46	4,795 66	3,890 75	8,686 41	3,885 01	3,568 30	7,453 31	18.06	17.17	36.03
St. Vincent's O. A., Santa Barbara	6	54	2,750 00	1,245 75	3,995 75	3,040 75	955 00	3,995 75	34.25	02.25	36.50
Santa Cruz Female O. A.	5	10	980 78	1,686 66	2,667 44	3,305 95	------	3,305 95	39.03	------	39.03
San Juan Roman Catholic O. A.	3	3	187 50	470 44	658 94	460 20	509 34	969 62	21.00	23.00	43.00
St. Vincent's O. A., Petaluma	7	28	1,330 75	450 00	1,780 75	2,118 50	1,985 25	4,103 75	16.59	15.30	31.83
Grass Valley O. A., Grass Valley	84	55	8,102 66	16,953 00	25,055 66	28,157 92	1,460 00	29,617 92	55.00	19.00	74.00
Pajaro Valley O. A., Watsonville	16	28	2,992 60	2,690 00	5,682 60	7,377 59	1,580 00	8,957 59	46.00	9.84	55.84
Los Angeles O. A.	7	18	618 02	2,419 42	3,037 44	1,540 99	6,621 60	8,162 59	11.03	24.01	35.04
Good Templars' Home for Orphans	16	58.3	5,519 32	5,758 59	11,277 82	5,509 92	4,097 79	9,607 71	20.41	14.05	34.46
Totals	------	------	$67,796 59	$64,833 46	$132,540 05	$99,821 39	$46,412 64	$142,244 93	------	------	------

EXTRACTS FROM REPORTS REGARDING COST OF MAINTAINING AN ORPHAN IN THE NECESSARIES OF LIFE.

From Ladies' Protective and Relief Society, San Francisco, Mrs. Jane H. Flint, Treasurer: "I give the following detailed statement that you can judge whether I have but included current expenses:"

Year ending September 1st, 1878.		Year ending September 1st, 1879.	
Food	$6,764 11	Food	$6,352 17
Clothing	2,444 53	Clothing	2,752 44
Fuel	181 90	Fuel	717 55
Water	117 00	Water	108 00
Attending and teaching	4,294 70	Attending and teaching	4,300 00
Medicine	173 70	Medicine	87 80
	$14,675 94		$14,317 96
Average number of children	185	Average number of children	196
Cost per child per annum	$79 33	Cost per child per annum	$73 05

The difference is partly due to the lower price in flour, fuel, and one or two other articles in 1879; partly to the circumstance that there were six old ladies in the Home in 1878, and only one in 1879, of the cost of whose maintenance no account has been taken. Medicine in 1878 includes funeral expenses of two preceding years, amount, $58.

EXTRACT FROM SAINT VINCENT'S ROMAN CATHOLIC ORPHAN ASYLUM FOR BOYS, SAN RAFAEL.

"Situated as Saint Vincent's is, owning a large tract of land, producing milk, butter, all kinds of vegetables and fruits in abundance, and having its shirts, sheets, and mattresses cut and made, in a great measure by unpaid labor, it is difficult to arrive at a precise estimate of what it costs to maintain a single orphan per day. However, taking the money put out for supplies as the sole basis of calculation, the following is a correct estimate of the cost for 1878 and 1879:"

Paid for flour	$9,750 00
Paid butcher	6,825 00
Paid for rice, beans, and potatoes	2,170 00
Paid for sugar, tea, and coffee	3,605 00
Paid for stationery	850 00
Paid for clothing	4,400 00
Paid for iron beadsteads	1,950 00
Paid for blankets, mattresses, etc.	4,120 00
Paid for painting, plumbing, etc.	5,380 00
Total expenses	$39,050 00

The average number of orphans maintained, 345; amount paid for the bare necessaries of life per annum was one-half of the gross amount for two years, or $19,875; divided by the number of orphans we have:

Cost in the necessaries of life per annum for the support of an orphan	$57 60
Other expenses, exclusive of buildings	36 50
Total cost per annum	$94 10
Cost per month	7 84¼
Cost per day	25¾

EXHIBIT 2.

The following tabulated reports show the number of orphans, half orphans, and abandoned children in the various Orphan Asylums January 1st, 1878, January 1st, 1879, January 1st, 1880, and the admissions and discharges during 1878 and 1879. These can be taken as very nearly correct. Taking the Controller's report of the number drawing aid for the year ending December 31st, 1879, which we annex further on, plus the excess in each asylum not drawing aid, the number January 1st, 1880, in the asylum verifies. The total admissions amount to 1,474; dismissions, 834; deaths, 15. This would make a gain of 619 children in the asylums, allowing the admissions of those not reported and dismissed, now about equal, which we know to be the case in the Ladies' Relief Society. The number of orphans reported January 1st, 1878, as 1,874, and January 1st, 1880, as 2,289, shows a gain of children in the asylum of 411. If, to this, we add the number of orphans over 14, which aggregate near 150, would make the number of orphans increase 560, which is as near as we can make these reports harmonize. With regard to this increase, we present a communication from Rev. Mr. James Croke, Superintendent of the San Rafael Orphan Asylum; also, an extract from the report of the Ladies' Protection and Relief Society of San Francisco, and one from the San Francisco Protestant Asylum:

EXTRACT FROM REPORT PROTESTANT ASYLUM, SAN FRANCISCO.

During the financial depression and unsettled condition of our industries for the past year, applications have been numerous from those who have never before been forced to seek assistance. Many a father, bereft of a mother's care for his children, and many a loving mother, with no strong arm to lean upon for assistance, out of health, out of work, and out of money, have asked a home for their children. To some this aid has been but temporary, while many others are still inmates of the asylum. We are happy to say, that, though the capacity of our institution has been fully tested, no worthy applicant has been refused admission, and we have been able to encourage many an aching heart. As we reported three years since, our work seems to be especially among *little* children, as most of the applicants are under six years of age, and those who visit the asylum are surprised to see so many of apparently the same age.

Our last year closed with 205 inmates at the asylum. Since that period 94 have been admitted, making 299 who have found a home with us; 46 of this number have been removed by their friends; 18 have been placed in families to be reared to lives of usefulness; 6 have been adopted by childless people, and 2 have been put to trades, leaving the present number in the institution 227—91 girls and 136 boys.

EXTRACT FROM REPORT LADIES' PROTECTION AND RELIEF SOCIETY, SAN FRANCISCO.

Owing to the prevalent destitution during the past year, resulting from the partial failure of the crops and other causes, we have had largely increased demands for assistance, and now, with burdened

hands and exhausted resources, we look to the public for such aid as shall render it possible for us to continue our benefactions. It is not to San Francisco alone that we appeal, but to every citizen of our State, whose heart can be touched by the misfortunes and sufferings of those who, through no sin of their own, are dependent upon the world's bounty.

We trust that the abundant harvests of the present year will incline the hearts of those who are reaping its fruits, to give a little of their plenty to this charity for little people. Whatever is suitable for family consumption will be welcome and useful in the Home; and, believing as we do, in the generous impulses of the human heart, we doubt not but there are many farmers in our State who need only a suggestion to induce them to respond freely to our call.

GENERAL REMARKS.

The year just elapsed, 1879, has been a trying year for some of the asylums, owing to the hard times and the difficulty in getting employment. Every one knows that the class of children sheltered in our orphan homes are, as a general rule, born of poor parents. In times of general depression, when the poor man can get no work, and the poor widow who usually makes a living for her little children by washing or house cleaning, is idle, our asylums become the only shelter for little ones who would otherwise suffer from hunger and neglect, whilst at the same time and for the same reason the amount contributed by parents is considerably less. Thus, you will notice that the number of children in St. Vincent's during 1879, particularly in the latter portion of it, was considerably greater than at any former period, whilst the receipts from charitable sources were a great deal less. (See receipts from private sources for 1878–79.) The number of children over fourteen is also greater on account of the difficulty of getting them homes, owing to the same cause, for few people, except the very rich, *who never take an orphan boy*, can afford to increase the number of their household. I generally give my boys away when I get a good safe home, provided they are fairly educated and are over twelve years. Unless adopted into a very good and comfortably circumstanced family I seldom give them out until they are approaching thirteen or fourteen years of age. Experience has taught me that, with rare exceptions, children given out before that age seldom do well. Too young to work or be of much use in a family their training is neglected, and they generally go astray. They should be adopted either when they are very young, or when they have arrived at an age to learn to make a living.

No matter how meritorious it may be to feed and educate our helpless waifs, and shield their younger days from harm and danger, or how generously our law-makers, by an enlightened and far-seeing policy, may aid in their support, it is my conviction that the greater part of the permanent and real good, both to society and the children, will be left *undone*, until we establish, in connection with our orphan asylums, schools of trade and industry, in which the children would learn at least the first elements of some mechanical or useful industry. Time does not permit at present to give the reasons, but they will easily suggest themselves to the reflecting and practical mind.

Impelled by this conviction, it is the intention of the writer, if

God spare him his health, to commence in the very near future an establishment that will supply this want. I believe that there is enough of charity in our State to start and support it, and that an appeal to our generous and high spirited community will be liberally responded to. I would consider that my life would be usefully spent in establishing, on a solid basis, an institution of that kind.

Most respectfully,

JAMES CROKE,
President St. Vincent's Orphan Asylum.

MARCH 2d, 1880.

EXHIBIT.

Showing number of orphans, half orphans, and abandoned children in the various orphan asylums, January 1st, 1878.

ASYLUMS.	Orphans	Half orphans	Abandoned children	Totals
San Francisco Roman Catholic Female, San Francisco	85	145	32	262
St. Joseph's Infant, San Francisco	27	130	48	205
St. Boniface, San Francisco	3	18	------	21
San Francisco Protestant, San Francisco	45	147	------	192
Ladies' Protection and Relief Society, San Francisco	13	61	146	220
Pacific Hebrew, San Francisco	19	40	10	69
Oakland Ladies' Protective and Relief Society, Oakland	3	27	12	42
San Juan Catholic, San Juan	1	6	6	13
Sacramento Protestant, Sacramento	9	41	10	60
Good Templars' (Protestant) Home for Orphans, Vallejo	18	60	------	78
St. Vincent's Catholic (Boys), San Rafael	------	------	------	358
St. Vincent's Catholic, Petaluma	8	30	------	38
St. Vincent's Catholic, Santa Cruz	5	17	8	30
St. Vincent's, Santa Barbara	3	37	------	40
Pajaro Valley Catholic, Watsonville	14	53	5	72
Grass Valley Catholic, Grass Valley	78	32	10	120
Los Angeles Catholic, Los Angeles	------	------	------	50
Totals	331	844	287	1,870

EXHIBIT.

Showing the number of orphans, half orphans, and abandoned children in the various orphan asylums, January 1st, 1879.

Asylums.	Orphans	Half orphans	Abandoned children	Totals
San Francisco Roman Catholic Female, San Francisco	79	162	30	271
St. Joseph's Infant (Roman Catholic), San Francisco	37	194	45	276
St. Boniface (Roman Catholic), San Francisco	6	7	3	16
Ladies' Protection and Relief Society (Protestant), San Francisco				200
San Francisco Protestant, San Francisco	43	461		204
Oakland Ladies' Relief Society (Protestant), Oakland	6	42	25	73
Pacific Hebrew, San Francisco	20	41	10	71
Sacramento Protestant, Sacramento	10	48	5	63
Good Templars' Home for Orphans (Protestant), Vallejo	19	76		95
San Juan Roman Catholic, San Juan	1	6	6	13
St. Vincent's Roman Catholic, San Rafael	114	228	50	392
St. Vincent's Roman Catholic, Santa Cruz	7	20	5	32
St. Vincent's Roman Catholic, Petaluma	10	35		45
St. Vincent's Roman Catholic, Santa Barbara	3	32	2	37
Pajaro Valley, Watsonville	14	57	3	74
Los Angeles, Los Angeles	14	42	9	65
Grass Valley, Grass Valley	84	40	30	154
Totals	467	1,191	223	2,081

EXHIBIT.

Showing number of orphans, half orphans, and abandoned children in the various orphan asylums, January 1st, 1880.

Asylums.	Orphans	Half orphans	Abandoned children	Totals
San Francisco Roman Catholic Female, San Francisco	74	189	28	291
St. Joseph's Infant (Catholic), San Francisco	39	215	62	326
St. Boniface (Catholic), San Francisco	3	20	4	27
Ladies' Protection and Relief Society (Protestant), San Francisco	9	90	101	200
San Francisco (Protestant), San Francisco	35	192		227
Pacific (Hebrew), San Francisco	20	41	10	71
Oakland Ladies' Relief Society (Protestant), Oakland	6	57	37	100
Sacramento (Protestant), Sacramento	10	75	5	90
Good Templars' Home for Orphans (Protestant), Vallejo	20	58	9	87
San Juan (Roman Catholic), San Juan	1	9	6	16
St. Vincent's (Boys', Roman Catholic), San Rafael	122	253	63	438
St. Vincent's (Roman Catholic), Santa Cruz	8	19	5	32
St. Vincent's (Roman Catholic), Petaluma	16	24		40
St. Vincent's (Roman Catholic), Santa Barbara	7	41	1	49
Pajaro Valley (Roman Catholic), Watsonville	15	59	2	66
Los Angeles (Roman Catholic), Los Angeles				67
Grass Valley (Roman Catholic), Grass Valley	59	106		165
Totals	444	1,477	333	2,289

EXHIBIT.

Showing the admissions and discharges of orphans, half orphans, and abandoned children.

Asylums.	Admissions, 1878.				Discharges, 1878.				Died.
	Orphans.	Half orphans.	Abandoned children.	Total.	Orphans.	Half orphans.	Abandoned children.	Total.	
San Francisco Roman Catholic Female	26	114	8	148	12	47	2	61	
St. Joseph's Infant, San Francisco	14	85		99	4	21		25	3
St. Boniface, San Francisco	2	4		6	1	6		7	
Protestant Orphan Asylum, San Francisco	19	68		87	21	54		65	
Ladies' Protection and Relief Society, San Francisco*									
Pacific Hebrew, San Francisco				† 14				‡ 3	
Ladies' Relief Society, Oakland	3	41	25	69	1	42	6	49	
Good Templars' Home for Orphans, Vallejo	1	30		31	1	22		23	
Protestant Asylum, Sacramento	5	67	7	79	11	47	9	57	9
St. Vincent's, San Rafael*									
St. Vincent's, Petaluma	2	7		9		2		2	
St. Vincent's, Santa Barbara					5			5	
St. Vincent's, Santa Cruz	1	6	8	15	1		6	7	
Pajaro Valley, Watsonville				† 30				12	
Grass Valley, Grass Valley	50	37		87	27	43		70	
San Juan (St. Joseph's), San Juan*									
Los Angeles, Los Angeles	10	32	8	50				‡ 25	
Totals	133	491	56	724	85	284	23	411	12

* Not reported. † Admissions. ‡ Discharges.

EXHIBIT.

Showing the admissions and discharges of orphans, half orphans, and abandoned children.

Asylums.	Admissions, 1879. Orphans.	Admissions, 1879. Half orphans.	Admissions, 1879. Abandoned children.	Admissions, 1879. Total.	Discharges, 1879. Orphans.	Discharges, 1879. Half orphans.	Discharges, 1879. Abandoned children.	Discharges, 1879. Total.	Died.
San Francisco Roman Catholic Female	30	87		117	4	16		20	
St. Joseph's Infant, San Francisco	19	92	52	163	17	71	25	113	
St. Boniface, San Francisco	7	6		13	2	6		8	
San Francisco Protestant, San Francisco	16	84		100	21	54		75	
Ladies' Protection and Relief Society, San Francisco*									
Pacific Hebrew, San Francisco				† 9				‡ 4	1
Ladies' Relief Society, Oakland*									
Good Templars' Home for Orphans, Vallejo	35		9	44		33		33	1
Sacramento Protestant, Sacramento	2	65		67	2	43	2	47	
St. Vincent's Catholic (Boys), San Rafael*									
St. Vincent's, Petaluma	6	10		16		12		12	
St. Vincent's, Santa Barbara	5	9		14	1	1		2	
St. Vincent's, Santa Cruz	3	8	3	14	1	5		6	
Grass Valley, Grass Valley	49	55		104	27	37		64	
Pajaro Valley, Watsonville				† 21				‡ 16	1
San Juan (St. Joseph's), San Juan	3			3					
Los Angeles, Los Angeles	14	42	9	65				30	
Totals	189	458	73	750	75	278	27	430	3

* Not reported. † Admissions. ‡ Discharges.

EXHIBIT 3.

EDUCATION.

With regard to the education of the orphans, as we had not the time to examine into it particularly, we append extracts from the report of the Grass Valley Orphan Asylum, and also from the Ladies' Protection and Relief Society of San Francisco, the Good Templars' Home for Orphans, the Ladies' Relief Society of Oakland, the Protestant Orphan Asylum of Sacramento; also, the Pacific Hebrew of San Francisco educate their children in the public schools. We are informed by the Superintendent of Public Schools of San Francisco that school facilities are furnished to all who apply.

FROM THE LADIES' PROTECTIVE AND RELIEF SOCIETY OF SAN FRANCISCO.

"Conducted by efficient teachers, we have a school numbering 140, which compares favorably with the public schools of our city. The pupils are faithfully instructed in the branches of an English education, and if they have ability and ambition, it will not be difficult for them to become intelligent men and women."

FROM THE GRASS VALLEY ORPHAN ASYLUM REPORT.

"The educational system of this institution includes seven separate grades, with distinct school rooms, and extending from the primary to the most advanced one, in which are taught composition, rhetoric, philosophy, book-keeping, algebra, etc.

"Special attention is paid to spelling, arithmetic, reading, and letter writing. To the latter, one day weekly is devoted, even in the junior classes. Each little one capable of writing a word is obliged to present her letter, and it will not be amiss to remark that many of them are *experts* (for their ages) in this branch.

"Music is also taught to such as manifest taste or talent for it, and among the Grass Valley orphans of to-day are to be found not a few who not only excel in cooking, washing, ironing, darning, dress-making, letter writing, etc., but whose musical accomplishments are, to say the *least*, creditable. These girls, on leaving the convent, are provided with situations as governesses, or teachers.

"The text-books, with the exception of the Readers, are the same as those now used in the public schools.

"Several hours each day are devoted to sewing, the little ones being obliged, from an early age, to assist in mending, darning, and caring for their own clothing, while the older pupils devote themselves to dress-making, etc. All branches of needle work, plain and ornamental, are taught."

EXHIBIT 4.

Abstract of the cost of the several asylums, acres of land attached thereto, etc.:

PACIFIC HEBREW ORPHAN ASYLUM, SAN FRANCISCO.

The society owns a tract of land in the County of San Francisco of 12 acres, cost of the same	$22,500 00
Cost of the lot, asylum building, and furnishing the same	85,036 17
Capital of the society paid up	98,722 97
	$183,759 04

They have 71 children in the asylum, a very ample provision this for their support and maintenance.

GOOD TEMPLARS' HOME FOR ORPHANS.

Twenty acres of land, cost	$1,000 00
Cost of building	30,000 00
	$31,000 00

SAN FRANCISCO PROTESTANT ORPHANS' HOME.

Owns a block of ground in San Francisco, value not given. Cost of building about $50,000. The society declines further information, deeming it a private matter.

LADIES' PROTECTIVE AND RELIEF SOCIETY OF OAKLAND.

Owns a valuable tract of 10 acres in East Oakland, on it a two-story building, used for an asylum. Value $30,000.

GRASS VALLEY ORPHAN ASYLUM, GRASS VALLEY.

Owns 12 acres of land in Grass Valley. Value unknown. Original cost of buildings, $83,000; amount debt, $5,000. Stock, 12 cows; 17 swine.

SANTA CRUZ ORPHAN ASYLUM, SANTA CRUZ.

Cost of buildings	$17,950 00
Approximate value of land	10,000 00
	$27,950 00

Is in debt $8,350. The San Francisco Roman Catholic Asylum loaned this asylum, January 1st, 1880, $6,000, to pay the debt due.

LOS ANGELES ORPHAN ASYLUM, LOS ANGELES.

This asylum owns a tract of 12 acres. Present value unknown. Cost	$11,000 00
Cost of asylum building	21,621 00
	$32,621 00

Owns a tract of four and a half acres in San Diego. Present value not known. Derives no benefit from it.

PAJARO VALLEY ORPHAN ASYLUM, WATSONVILLE.

This asylum owns a tract of 140 acres. Value and cost unknown. Cost of building and improvements, $18,000; under the management of the Franciscan Fathers.

ST. BONIFACE ORPHAN ASYLUM, SAN FRANCISCO.

Value of lot and building, $13,000. A debt thereon of $5,000.

ST. VINCENT'S ORPHAN ASYLUM, SANTA BARBARA.

This asylum owns 300 acres of land.

Cost of same and improvements	$3,300 00
Building cost	45,000 00
Four acres land therewith	4,000 00
	$49,300 00

LADIES' PROTECTION AND RELIEF SOCIETY, SAN FRANCISCO.

This society owns a block on Van Ness Avenue, Post, Geary, and Franklin Streets.

Value of block	$225,000 00
Value of building	45,000 00
	$270,000 00

SAN FRANCISCO ROMAN CATHOLIC ASYLUM, SAN FRANCISCO.

Owns a tract of sixty acres in San Francisco. Value unknown, nor cost of same. Cost of asylum building, $227,000. It has about fifty cows and young stock.

ST. JOSEPH'S INFANT ORPHAN ASYLUM, SOUTH SAN FRANCISCO.

Owns five acres of land; original cost, $1,800. Present value not known.

Cost of asylum building	$50,000 00
Improvements	12,000 00
	$63,800 00

ST. VINCENT'S, SAN RAFAEL.

Owns a tract of 316 acres; value, unknown. J. O'Brien bequeathed it $50,000. Cost of asylum, $75,000.

EXHIBIT 5

DISBURSEMENTS BY THE CONTROLLER ON ACCOUNT OF ORPHANS.

We herewith append a statement from the Controller's office of the amounts paid to the various orphan asylums, the twenty-eighth, twenty-ninth, and thirtieth fiscal years. Also, a statement of the amounts paid the second quarter of the thirtieth fiscal year, ending December 31st, 1878, and the second quarter of the thirty-first fiscal year, ending December 31st, 1879.

We find the increase of money paid to the orphan asylums the thirtieth over the twenty-eighth fiscal year to be $35,477 98. The increase for quarter ending December 31st, 1879, over the quarter ending December 31st, 1878, to be $4,015 58, plus the amount due Ladies' Relief Society of Oakland, say, $1,500, would equal $5,515 58. We may safely calculate the increase of the amount to be paid this fiscal year over the last to be not less than $25,000, probably $30,000, and total for the year $160,000.

EXHIBIT.

Showing the number of orphans, half orphans, and abandoned children drawing aid from the State, in various asylums, the second quarter of the thirtieth and thirty-first fiscal years, ending December thirty-first, and the amount drawn by such orphan asylums for the said quarter years.

NAME AND LOCATION.	1879. Orphans	1879. Half orphans	1879. Abandoned children	1879. Total	1879. Amounts paid	1880. Orphans	1880. Half orphans	1880. Abandoned children	1880. Total	1880. Amounts paid
San Francisco Roman Catholic Orphan Asylum, San Francisco	70	183	19	272	$5,112 25	77	200	21	298	$5,741 30
St. Joseph's Infant, San Francisco	36	175	------	211	3,844 53	36	186	15	237	4,397 53
St. Boniface, San Francisco	3	18	3	24	315 61	3	15	3	21	390 60
Ladies' Protection and Relief Society Orphan Asylum, San Francisco	11	87	22	120	2,048 43	11	90	25	126	2,273 48
Ladies' Relief Society, Oakland	------	------	------	------	------	------	------	------	------	------
Protestant Orphan Asylum, San Francisco	50	169	------	219	3,954 60	36	200	------	236	4,334 60
Pacific Hebrew, San Francisco	10	37	------	47	911 45	12	28	------	40	825 00
Good Templars' Home for Orphans, Vallejo	23	59	------	82	1,528 92	19	75	------	94	1,748 80
Pajaro Valley Orphan Asylum	13	53	------	66	1,269 30	13	57	------	70	1,326 07
St. Vincent's Roman Catholic, San Rafael	124	210	------	334	6,522 74	122	253	------	375	7,380 25
St. Vincent's, Santa Cruz	5	16	------	21	425 00	7	18	------	25	512 50
St. Vincent's, Petaluma	12	25	------	37	761 85	16	19	------	35	756 25
St. Vincent's, Santa Barbara	3	32	------	35	675 00	7	37	------	44	823 21
Grass Valley, Grass Valley	96	46	------	142	2,957 07	59	106	------	165	3,483 91
Los Angeles, Los Angeles	8	30	------	38	678 94	11	45	------	56	899 74
Protestant Orphan Asylum, Sacramento	6	67	------	73	1,292 72	7	73	------	80	1,420 75
St. Joseph's, San Juan	------	------	------	------	------	------	------	------	------	------
Totals	470	1,207	44	1,721	$32,298 41	436	1,402	64	1,902	$36,313 99

EXHIBIT.

Showing the amounts paid by the State to the various orphan asylums.

Asylums.	The 28th fiscal year.	The 29th fiscal year.	The 30th fiscal year.
San Francisco Protestant Orphan Asylum, San Francisco	$13,647 55	$15,191 22	$16,485 93
Ladies' Protection and Relief Society Orphan Asylum, San Francisco	3,750 00	------------	8,294 54
San Francisco Roman Catholic Female Orphan Asylum, San Francisco	17,153 64	18,050 45	20,844 31
St. Joseph's Branch, San Francisco	10,613 16	13,734 57	16,713 37
St. Boniface, San Francisco	622 97	1,345 83	1,341 67
Pacific Hebrew, San Francisco	3,086 83	3,900 91	3,652 50
Oakland Ladies' Relief Society, Oakland	------------	------------	1,802 81
Sacramento Protestant Orphan Asylum, Sacramento	4,912 18	4,775 53	4,815 72
St. Joseph's, Catholic, Sacramento	828 98	610 10	1,785 74
St. Vincent's Orphan Asylum, San Rafael	20,219 99	24,460 61	26,414 12
St. Vincent's Orphan Asylum, Petaluma	1,656 25	1,984 05	2,741 40
Good Templars', Vallejo	5,519 32	6,118 31	6,604 55
Grass Valley, Grass Valley	10,864 05	9,647 41	11,597 26
Pajaro Valley, Watsonville	3,386 44	3,944 94	5,031 60
St. Vincent's, Santa Cruz	978 58	1,497 33	1,636 59
St. Vincent's, Santa Barbara	2,405 75	2,760 55	2,769 62
Los Angeles, Los Angeles	------------	2,128 07	2,819 25
San Juan, San Juan	187 50	612 50	------------
Totals	$99,872 79	$110,762 38	$135,350 98

EXHIBIT 6.

Herewith is presented the total amounts of cash received by the Orphan Asylums for the years 1878 and 1879, and total disbursements of the same as compiled from their reports; also, the nativities of the parents of the children as reported by the asylums.

This charity represents property in the aggregate of $1,500,000. There are in the asylums now 2,280 children, and the amount necessary for their maintenance the next year, in total, will be $228,000, exclusive of new buildings and improvements, allowing $100 to be necessary for the support of each child.

Our country is now easy of access, and the worthless, the vicious, as well as the poor and unfortunate of other lands, flock into it, only to find that here, as elsewhere, he who would eat, must labor; consequently the doors of our charitable institutions are besieged with applicants for bounty, and their wards filled to overflowing with those from whom it were cruel to withhold assistance, even when it is evident that their condition is due to their own indolence, improvidence, and too often, crime.—[Report Ladies' Relief Society.

EXHIBIT.

Showing the nativity of parents of the orphans and half orphans, and abandoned children.

Asylums.	No. of children	One or both parents American.	Both parents foreign.	Unclassified.
San Francisco Roman Catholic O. A., San Francisco	291	40	251	---------
St. Joseph's Roman Catholic O. A., San Francisco	326	50	276	---------
St. Bonifice Roman Catholic O. A., San Francisco	27	------------	27	---------
St. Vincent's Roman Catholic O. A., San Rafael	438	118	277	43
St. Vincent's Roman Catholic O. A., Santa Cruz	38	8	24	---------
Pajaro Valley Roman Catholic O. A., Watsonville	66	22	44	---------
Los Angeles Roman Catholic O. A., Los Angeles	65	20	45	---------
Pacific Hebrew, San Francisco	71	------------	71	---------
Protestant O. A., San Francisco	227	56	171	---------
Ladies' Protection and Relief, San Francisco	200	90	110	---------
Ladies' Relief Society, Oakland	100	42	58	---------
Protestant Orphan Asylum, Sacramento	90	30	60	---------
Grass Valley Roman Catholic O. A., Grass Valley	165	26	128	11
Good Templars' Home for Orphans, Vallejo	82	78	4	---------
Totals	2,160	580	1,546	54

EXHIBIT.

Showing receipts of the various orphan asylums from the State and private sources.

Asylums.	Average No. children	Money received from the State. 1878.	Money received from the State. 1879.	Money received from the State. Total.	Money received from private sources. 1878.	Money received from private sources. 1879.	Money received from private sources. Total.
San Francisco Roman Catholic	281	$22,769 69	$21,701 26	$44,470 86	$16,708 45	$16,249 29	$32,957 34
St. Joseph's Infant, San Francisco		14,377 46	17,664 71	32,042 17	11,045 33	12,744 00	23,789 33
Grass Valley		10,727 60	13,592 25	24,326 85	16,824 24	12,960 49	29,783 73
San Rafael		25,229 00	27,560 00	52,789 00	14,214 00	12,686 00	26,900 00
St. Vincent's, Petaluma		2,530 10	2,821 18	5,331 28	240 00	462 00	702 00
St. Vincent's, Santa Cruz		1,447 30	1,781 86	3,229 16	1,966 07	2,190 65	4,156 72
St. Vincent's, Santa Barbara		2,768 75	2,960 84	5,729 59		90 00	90 00
Los Angeles		2,283 85	2,519 53	4,803 38	1,994 00	1,318 60	3,312 60
Pajaro Valley, Watsonville		4,495 05	5,181 34	9,676 39	3,161 20	1,953 96	5,115 16
St. Boniface, San Francisco		664 00	1,870 41	2,534 41	98 00	590 00	688 00
				$184,053 09			$127,494 88
San Francisco Protestant Orphan Asylum		19,272 32	20,906 39	$40,178 71	14,533 89	20,906 39	$34,440 28
Sacramento Protestant Orphan Asylum		5,864 09	4,031 80	9,895 89	10,183 43	3,890 60	14,074 03
Good Templars' Home for Orphans		5,519 32	6,118 31	11,637 63	9,197 85	8,136 77	17,334 62
Ladies' Protection and Relief Society, Oakland		500 00	1,802 81	2,302 81	4,102 47	6,460 97	10,563 44
Ladies' Relief Society		5,135 94	7,372 48	12,567 82	11,680 81	9,337 57	21,018 33
Pacific Hebrew		3,902 56	3,944 94	7,847 50	18,435 00	40,360 07	58,795 07
				$84,430 36			$156,225 77
				$268,483 45			$283,720 65

EXHIBIT

Of disbursements of the Asylums in the necessaries of life, compiled from their reports—1879.

Asylums.	Location.	No. of children.	Groceries.	Clothing.	Water and gas.	Medicine.	Stationery.	Washing and sundries.	Totals.
St. Joseph's Infant	San Francisco	326	$12,758 67	$3,073 70	$972 40	$59 00	$55 80		$16,919 57
St. Vincent's	San Rafael	438	11,175 00	2,200 00			425 00		13,800 00
Pajaro Valley	Watsonville	66	6,209 00	700 00	780 00				7,689 00
Los Angeles	Los Angeles	67	1,550 00	1,023 24	325 00				1,898 24
Santa Cruz	Santa Cruz	32	2,371 04	755 84	303 68	81 76	116 80	268 64	3,897 76
St. Vincent's	Petaluma	40	1,257 30	503 00	370 00 184 00	67 42	296 27	235 75	2,913 44
St. Vincent's	Santa Barbara	49							789 36
San Francisco Protestant	San Francisco	229	9,744 46	2,500 00	1,595 55				13,840 01
Ladies' Protection and Relief	San Francisco	200	6,352 17	2,752 44	825 55	87 80			10,071 96
Ladies' Relief Society	Oakland	100	1,208 15	504 50	49 50		22 65		1,762 15
Good Templars' Home for Orphans	Vallejo	87	3,379 42	851 06	450 27	68 50	16 12		4,788 02
Pacific Hebrew	San Francisco	71							8,685 94
Totals		1,601							$87,055 45

EXHIBIT

Of disbursements of the Asylums, exclusive of the necessaries of life, compiled from their reports—1878.

NAME.	Location.	No. of children.	Bedding and furniture.	Taxes.	Improvements.	Repairs.	Pay-roll and salaries.	Miscellaneous expenses.	Totals.
St. Joseph's Infant	San Francisco		$1,254 47	$135 00	$3,144 20	$412 78	$350 00 1,943 15	$128 35 1,951 82	$9,319 77
St. Vincent's	San Rafael		3,025 00		10,937 50	2,690 00			26,412 50
Pajaro Valley	Watsonville			207 25			9,750 00		1,887 25
Los Angeles	Los Angeles			794 91			1,680 00		1,578 49
Santa Cruz (St. Vincent's)	Santa Cruz		32 85				783 58		54 70
St. Vincent's	Petaluma		359 07					21 90	359 07
St. Vincent's	Santa Barbara				2,120 00				2,120 00
San Francisco Roman Catholic	San Francisco	291		860 00	4,103 15				7,563 15
San Francisco Protestant	San Francisco		2,300 00	1,937 47	6,634 95		2,600 00		17,797 82
Ladies' Protection and Relief Society	San Francisco		436 05	1,420 34		784 30	5,758 50	1,166 90	7,073 89
Ladies' Relief Society	Oakland		204 90	184 00	644 88		4,294 70	138 50	3,105 00
Good Templars' Home for Orphans	Vallejo		225 00	363 00	2,584 01	377 02		2,071 22	9,122 17
Pacific Hebrew	San Francisco						3,779 25	1,793 89	6,280 00
Total									$92,673 81

EXHIBIT

Of disbursements of the Asylums, in the necessaries of life, compiled from their reports—1878.

NAME.	Location.	No. of children.	Meats and groceries.	Clothing.	Water, fuel, and gas.	Medicines.	Stationery.	Washing and sundries.	Totals.
St. Joseph's Infant Asylum	San Francisco	262	$12,491 55	$2,521 44	$819 17	$95 25	$105 92		$16,033 33
St. Vincent's	San Rafael	358	11,175 00	2,200 00			425 00		13,800 00
Pajaro Valley	Watsonville	72	6,237 00	900 00	654 00				7,791 00
Los Angeles	Los Angeles	50	1,416 75	982 61	250 00				2,649 36
Santa Cruz	Santa Cruz	30	2,255 70	689 75	240 90	21 95	43 80	$273 75	3,525 85
St. Vincent's	Petaluma	38	916 30	557 15	405 17	45 10	367 21	144 00	2,434 93
St. Vincent's	Santa Barbara	40							789 36
San Francisco Protestant	San Francisco	192	10,642 40	2,445 00	1,609 85				12,697 25
Ladies' Protection and Relief Society	San Francisco	220	6,764 11	2,444 53	117 00 881 90	173 70			10,381 24
Ladies' Relief Society	Oakland	42	786 19	360 41	70 00				1,216 60
Good Templars' Home for Orphans	Vallejo	78	3,695 25	593 94	835 12	95 02	40 55		5,259 88
Pacific Hebrew	San Francisco	69							8,883 06
Totals		1,451							$85,461 86

EXHIBIT

Of disbursements of the Orphan Asylums, exclusive of the necessaries of life, compiled from their reports—1879.

Name of Asylum.	Bedding and Furniture.	Insurance and taxes.	Improvements.	Repairs.	Pay roll and salaries.	Miscellaneous expense.	Totals.
St. Joseph's Infant, San Francisco	$1,232 06	$159 05	$3,664 25	$544 79	$2,883 00	$1,360 00	$8,994 13
St. Vincent's, San Rafael	3,035 00		10,937 50	2,690 00	9,750 00		26,412 50
Pajaro Valley, Watsonville		195 65			960 00		1,155 65
Los Angeles, Los Angeles		689 89			321 50		1,011 39
Santa Cruz, Santa Cruz	105 12				220 00		325 12
St. Vincent's, Petaluma	482 25						482 25
St. Vincent's, Santa Barbara			2,120 00				2,120 00
San Francisco Roman Catholic		125 00	17,738 21		2,925 25		20,788 46
San Francisco Protestant	2,278 66	1,083 66		2,843 89	5,777 00	560 00	12,543 21
Ladies' Protection and Relief Society	658 39	667 04		258 39	4,300 00	149 05	6,032 87
Ladies' Relief Society	193 45	142 00	546 00	231 30	1,524 50		2,637 25
Good Templars' Home for Orphans	543 55	358 00	1,690 59	392 57	3,993 55	901 17	7,970 43
Pacific Hebrew							6,297 00
Total							106,800 26

Recapitulation—1878 *and* 1879.

Total received from State	$268,583 45	
Total received from private sources	283,720 65	
		$552,204 10
Amount expended in necessaries for orphans	$142,517 31	
Amount expended exclusive of necessaries for orphans	199,474 07	
Expended by Roman Catholic Orphan Asylum, San Francisco, not itemized	49,709 90	
Expended by Grass Valley Orphan Asylum	59,111 58	
Expended by Saint Boniface Orphan Asylum	4,140 25	
Expended by Sacramento Protestant Orphan Asylum	21,573 01	
		$476,526 12
Pacific Hebrew, cost to capital	$36,496 51	
Unexpended balances and amounts unaccounted for	39,181 47	
		75,677 98
Total		$552,204 10

PETITION TO THE LEGISLATURE

BY THE

FISHERMEN OF SAN FRANCISCO AND VICINITY,

ASKING THE

Abolishment of the Close Season of Salmon Fishing.

INDORSED BY THE EXECUTIVE BODY OF THE SALMON FISHERMEN'S ASSOCIATION OF SAN FRANCISCO.

PETITION.

To the Honorable the members of the Senate and Assembly of the State of California:

We, the undersigned, salmon fishermen and parties materially interested in the business of salmon fishery and its successful prosecution in the waters of the Sacramento River, and the interentrant bays and rivers affluent to the Bay of San Francisco, do most respectfully represent to your honorable bodies, respectively:

That by reason of the law of the State prohibiting the taking of salmon between the first day of August and the fifteenth day of September, the salmon harvest of the summer and autumn seasons is prevented, and a production interdicted greater than it is ever possible to make during all the other time that intervenes between the first day of July and the first day of the next succeeding April;

That this prohibition is not necessary for the protection of the salmon within reasonable business-like requirement, and that it is oppressive and cruel to the producers who make salmon fishing a business and means of subsistence to themselves and families, in this, that nearly one-half the proceeds of their yearly industry is cut off thereby;

That we are convinced, from long experience and observation, that the cessation of fishing during thirty-six hours in each week would give ample opportunity for the passage undisturbed of all the salmon required for the purpose of seeding and propagation, and that no extended close season is ever required for that purpose;

Therefore, your petitioners ask that the law may be so amended that there shall be no prohibition against salmon fishing except between the rising of the sun on Saturday, and the setting of the sun on the next succeeding Sunday, throughout the year.

And your petitioners will ever pray, etc.

PETER VERGADA,
GERMANO TILLI,
SANERIO MARSICH,
CESARE MALAPIONI,
F. DELMONTE,
C. SALVERIO,
G. BASSADOMIE,
F. DELMONTE,
JOSEPH MILLION,
COSTANTINO OMATO,
DOMINICO VENTURO,
GIORGI MICHONO,
PETER PARTIGNI,
JOHN CATCHMAN,
GION NICLIS,
GION GALETA,
G. BETTINI,
CRIST ALEX,
A. GORGI,
DIMITRI SUCA,
GION SCARPIRILLY,
N. V. DROBRAZ,

GIOSEPH VITTOLANO,
SERAFFINO MALATESTA,
GOITTANO VALAZOLO,
GIROLOMO LORETTINO,
FASINI RUCHETTA,
PAONE TOMASSO,
A. MALATESTA,
GIOVANNI PRIMAVERA,
LUEGI COLANGIO,
CALI FAITIGERS,
WILLIAM HOSKING,
WILLIAM PAGE,
J. C. BOND,
QUARTORARO SALVATORE,
GIORGI PERIZ,
G. PASSALACQUA,
MICHEL APERGI,
G. MARCHETTA,
PETER FRANCK,
GIORGI PITER,
FRANK GALLI,
PETER MONTE,
A. SCAFFARI,
GION MIMACHI,
CRISTO LOFISTI,
GAETANO VIZENZO,
J. W. ARNOLD,
F. V. KEITH,
JOHN FLORIO,
GION ZACH,
C. E. AURILIO,
ROSARIO GIUNTA,
AGOSTINO NOTO,
ANTONE BOTZ,
FRANCESCO ROMANO,
ANDREA SCUDER,
STEFANO CICERELLO,
G. PAVOLINI,
G. GARAGNELLA,
P. BARGION,
A. W. CORNWALL,
WALTER PARSONS,
AARON SENDERMAN,
ANDREW DACKER,
C. LAGOMARSINO,
GIORGI DEVIS,
WILLIAM T. ODEN,
M. HOMBURG,
J. RIO BAKER,
G. C. CARMAN,
GECK LICURGO,
CASIMO CARAPALO,
H. PEERS,
GEORGE ELIO,

BENZZONE GIUSSEPPE,
MARIANO CASIPPO,
PETER GORGE,
ANASTASIO COSTANTINO,
GION LUIS,
PETER SHAUGHNESSY,
NIELS ANDERSON,
EMIGLIO NAZICOMI,
GION CRIST,
GIOSEF LISTER,
GIACOMO CORSO,
GION PITERS,
GION LUCAS,
CARLO ROMEO,
HUNZIO TYRANO,
VASILO RICIARDELLI,
CARMELO RICIADELLI,
CHRISTOPH. HARTMAN,
E. MONDAINI,
G. RICIOLO,
G. GIONANTONIO,
V. CAROSO,
L. M. UPHAM,
B. B. BROWN,
WILCOX, RUBLE & DOZIER,
ERLANGER & GALINGER,
L. FALLMAN,
F. S. FALLMAN,
DANIEL McGRAUGH,
J. B. FISCUS,
JOHN D. INGERSOLL,
J. GUMEE,
WILLIAM WADSWORTH,
JAMES U. CHASE,
J. M. PERRY, Merchant,
GEORGE A. CLURRIDGE,
W. SMYTH,
GEORGE THOMPSON,
JAMES DOBBINS,
THOMAS ALLISON,
A. H. PETERSON,
WILLIAM FERGUSON,
H. LAWSON,
S. NIELSEN,
JAMES SMITH,
W. C. PALMER,
LEWIS CHASE,
S. R. MATHEWSON,
JOHN M. NYRON,
M. CHRISTENSEN,
JOSEPH BRUNING,
J. H. GARDINER,
JOHNSON & ENGLISH,
SAMUEL N. NORTON.

INDORSEMENT OF THE FOREGOING PETITION.

SALMON FISHERMEN'S ASSOCIATION OF SAN FRANCISCO,
IN EXECUTIVE BODY AT OFFICE, RIO VISTA,
Regular Term, December 6th, 1879.

It appearing to this body that a petition addressed to the Honorable Senate and Assembly of the State of California, praying for certain reforms in the laws of the State relating to salmon fishery, has been numerously signed by substantial citizens, interested in the preservation and successful prosecution of the business of salmon fishing, and by many genuine salmon fishermen, chiefly members of our worthy Salmon Fishermen's Association of San Francisco, and the purport and prayer of said petition being fully concurred in by the unanimous voice of the members of this body; therefore, it is ordered by the executive body of the Salmon Fishermen's Association of San Francisco, that said petition be spread in full upon the minutes of the body, and that a copy of these orders be thereto attached and therewith transmitted to the Legislature, through the most convenient and appropriate channel.

It is further ordered, that the whole power of the associative organization of the Salmon Fishermen's Association of San Francisco is hereby pledged in behalf of the law and its strict fulfillment and execution, when amended as justice requires and common sense dictates. And it is

Resolved, That during any year or season of the past, that may be taken as an example, the utmost efforts of the State and county authorities have most pitifully and egregiously failed to enforce the law as a rule, but the effect has been to deter law-abiding persons from pursuing an honest industry, and thus offer a premium chance to those who care not for but dare the law. And we aver that the efforts of the members of the Salmon Fishermen's Association of San Francisco, when directed under the orders of their associative agents and trustees, can hardly fail of complete success in sustaining and enforcing the law within the jurisdiction of the Association. (See copy Constitution of Association herewith, Article I, Section 3.)

Resolved, That with all due respect for science that has reached the fruit-bearing stage, and with all due tenderness for its fickle and dangerous earlier stages, we submit to the attention of the Honorable Senate and Assembly that the salmon fishermen of the Sacramento, San Joaquin, and the waters adjacent have suffered these many years from the clinics of experimental pisciculture, as practiced by the State Fish Commission, when causing the enactment by the Legislature of laws withholding from the fishermen the great August and September "run" of salmon, and thus compelling them to lie idle during the proper and very best season for their business, or become criminal in the eyes of the law; and with all proper respect for that Commission—who have done some good things—we respectfully ask them through their creator, the Legislature, to let the salmon business be governed somewhat by the judgment of the

fishermen, who know all there is of a practical nature in it, though they could not by a lifetime of talk and scribbling impart that knowledge to a mere student or rod fisherman, so that a just application would be made thereof by him. We are more directly interested in the preservation of the salmon in our waters than any other party or parties can be except the people of the State en masse, and we claim a voice in this matter.

Resolved, That these orders and resolutions, and the petition hereto attached, be approved in full as a part of our official record and declaration in this matter.

Office Salmon Fishermen's Association of San Francisco,
Rio Vista, December 6th, 1879.

I hereby certify that the above and foregoing is a full, true, and correct copy of the orders and resolutions this day made of record and remaining in this office, concerning the matters and things therein related and set down.

SAMUEL N. NORTON, Secretary.

PETITION TO THE LEGISLATURE

ASKING THE

Abolishment of the Close Season of Salmon Fishing.

INDORSED BY THE SALMON FISHERMEN OF SAN FRANCISCO AND VICINITY.

PETITION.

To the Honorable the members of the Senate and Assembly of the State of California:

We, the undersigned, salmon fishermen and parties materially interested in the success of the business of salmon fishery in the waters of the Sacramento River and the interentrant bays and rivers affluent to the Bay of San Francisco, do most respectfully represent to your honorable bodies, respectively:

That by reason of the law of the State prohibiting the taking of salmon between the first day of August and the fifteenth day of September, the salmon harvest of the summer and autumn season is prevented, and a production interdicted greater than it is ever possible to make during all the other time that intervenes between the first day of July and the first day of the next succeeding April.

That this prohibition is not necessary for the protection of the salmon within reasonable business-like requirement, and that it is oppressive and cruel to the producers who make salmon fishing a business and means of subsistence for themselves and families, in this, that nearly one-half the proceeds of their yearly industry is cut off thereby.

That we are convinced from long experience and observation that the cessation of fishing during thirty-six hours in each week would give ample opportunity for the passage undisturbed of all the salmon required for the purpose of seeding and propagation, and that no extended close season is ever required for that purpose.

Therefore, your petitioners ask that the law may be so amended that there shall be no prohibition against salmon fishing, except between the rising of the sun on Saturday and the setting of the sun on the next succeeding Sunday, throughout the year.

And your petitioners will ever pray, etc.

W. H. FREEMAN,
JAMES EWING,
SAM. W. DALTON,
CHAS. SPALDING,
W. KUHLAND,
L. W. KUHLAND,
G. A. HASTINGS,
JAMES CLYNE,
ANDREW GOODYEAR,
HUGH P. EDWARDS,
JOHN MOUNCE,
L. R. BROWN,
D. W. HARRIER,
CHARLES H. HUBBS,
CHARLES WIDENMANN,
PETER ROTHENBUSH,
CHAS. W. RILEY,
FRANCIS BRADY,
JOHN H. LAY,
A. J. McPIKE,
O. L. HENDERSON,
F. O'GRADY,
G. B. RICHART,
JAS. H. LAMONT,

DR. E. F. HAERDO,
JOHN RUEGER,
JAMES BARRY,
A. McDIVETT,
C. B. DEMING,
ALFRED DALTON,
A. W. FERGUSON,
C. B. HOUGHTON,
E. H. VON PFISTER,
W. F. HASTINGS,
D. N. HASTINGS,
F. P. WEINMANN,
JOHN FARNHAM,
O. H. BUTLER,
C. T. B. HALLIN,
JAMES BROWNLIE,
B. D. EGERY,
J. H. POWELL,
JOHN P. ERNST,
F. DIMINGER,
J. F. TOBIN,
J. R. ADEN,
M. J. WRIGHT,
JAMES TOPLEY,
W. F. ROE,
E. W. SUNDQUIT,
F. D. NEAL,
N. VANDERLIP,
B. BONDS,
A. S. CARMAN,
JOEL A. HARVEY.

PETITION

RELATIVE TO

SHRIMP FISHERY BY CHINESE.

TO THE LEGISLATURE, TWENTY-THIRD SESSION—1880.

PETITION.

SAN FRANCISCO, Cal., January 28th, 1880.

To the Honorable the members of the Senate and Assembly of California:

GENTLEMEN: The undersigned citizens and residents of San Francisco, and of other points around the Bays of San Francisco, San Pablo, and Suisun, respectfully call your attention to the following facts:

That they are each and all interested directly in the business of fishermen and original venders of their fish to the city markets; that they are mostly married men, with families dependent on their toil for that decent support which an American citizen should give to his wife and children; that they are taxpayers, and willingly bear their share of the public burdens; that they are equally desirous with their other fellow citizens to have any and every proper safeguard thrown about the legitimate conduct of their business, and the preservation of this great source of food supply; that they have carefully watched the course of legislation affecting fish and fisheries under the California game laws, and that they desire to call your especial attention to the following extracts from those game laws affecting this particular matter, viz.:

SECTION 5. Section six hundred and thirty-six of said Code is hereby amended so as to read as follows:

Section 636. Every person who shall set, use, or continue, or who shall assist in setting, using, or continuing any pound, weir, set net, trap, or other fixed or permanent contrivance for catching fish in the waters of any of the creeks, rivers, or sloughs of this State, is guilty of a misdemeanor.

Every person who shall draw or who shall assist in drawing any net or seine for the purpose of taking fish in any of the waters of this State, the meshes of which are less than one and one-fourth inches in size, is guilty of a misdemeanor; *provided,* that nets with a mesh of a smaller size may be used in the catching of shrimps.

Every person who shall cast, extend, or set any seine or net of any kind for the catching of fish in any river, stream, or slough of this State, which shall extend more than one-third across the width of said river, stream, or slough, at the time and place of such fishing, is guilty of a misdemeanor.

Every person who, by seine or other means, shall catch any fish so small as to be able to escape through a mesh of one and a half inches in size, or the young of fish of any species, but which at the time of capture are too small to be marketed, and who shall not return the same to the water immediately, and alive, or who shall sell or offer for sale any such fish, fresh or dried, is guilty of a misdemeanor.

That, as we think, it should be noticed, the peculiar language of the proviso and of the paragraph as to young or small fish which can

pass a mesh of 1½ inches or less in size, is calculated to defeat the very intent and laudable object of the prohibition against the use of too small a mesh; that it is too well known a fact to admit of controversy, that shrimp fishery is exclusively in the hands of the Chinese, who are the only ones benefited by the proviso referred to; that the catch and use of shrimps in amount and value are insignificant in comparison with the wanton destruction of valuable young and small fish which are caught by the so-called shrimp nets, and are destroyed without benefit to white men, or to larger fish for food; that under the law the burden of proof for convicting offenders is thrown upon the complainant, and when a Chinaman is the aggressor, such proof is almost impossible of attainment, as he will claim innocence of *intention* to destroy the young fish, and the protection of the proviso above referred to. Moreover, we call your attention to the practice of Chinese fishermen in covering every available fishing ground in shallow waters around the bays with stakes, to which they attach their nets, making actual traps, constantly set, for the fish; and to the other practice of drying the small fish along with shrimps, grinding the mass into a meal (which is winnowed for removing shells and scales) and baled in the name of "shrimps," for export to China and Australia, the amount of which far exceeds the ordinary information and belief.

It is notorious that our waters, which fifteen years ago afforded, for sport and industry, as fine fishing ground as the world could elsewhere show, now barely yield a decent competence in return for the toil, exposure, and courage of the fisherman.

We respectfully urge these matters upon your consideration, and ask that such proper legislation may be had as will remedy the evils to which we have referred; particularly that the language of the proviso, etc., may be so altered as to avoid any ambiguity in interpreting the law.

The entire community have interest in this matter; but, as fishermen, more directly affected and naturally more thoroughly advised of the evils complained of, and the manner of the men who commit these evils, we have deemed it right, in our capacity as fishermen, to address you this memorial.

We assure you that every personal effort on our part to give such aid in the premises, and to afford to your committees, separate or joint, the physical evidence that you may require, will be cheerfully given whenever called for, and that we will use all our influence to see the law fully complied with by others, who should be, as we claim to be, law-abiding citizens.

We remain, respectfully, etc.,

BEN. DON LEAVY	No. 220 Sixth Street.
S. E. MORTIMER	No. 1010 Mission Street.
IKE ASCH	No. 215 Sixth Street.
JAMES NORTON	No. 986 Harrison Street.
C. CANAVAN	Elbo Lodging House.
M. O'KEEFE	No. 323 Clementina Street.
J. L. BROWN	Stockton Street.
JOHN J. BROWN	No. 822 Eighth Street.
DAN. O'RAFFE	No. 26 Fifth Street.
W. E. MACREADY	No. 20 Fifth Street.
L. FEDERSPOOL	No. 515½ Fourth Street.

NICOLO VIOLICH	Long Bridge.
FREDERICK SMITH	Ariel R. Club, Long Bridge.
GEORGE MULVEY	No. 22 Bluxome Street.
HENRY WIGGETT	No. 322 Brannan Street.
JAMES GRIFFITHS	No. 9 Zoe Street.
NATHANIEL GRIFFITHS	No. 9 Zoe Street.
EDWARD MAGINIGAN	Corner Third and Berry Streets.
THOMAS SWEETMAN	Kentucky Street.
WILLIAM HENRY	No. 20 Pearl Street.
EDWARD NELSON	Fourth and Welsh Streets.
G. W. SPRING	Fourth and Berry Streets.
JOHN PETERS	Fourth and Berry Streets.
JAMES CURRAN	Fourth and Berry Streets.
JOS. PAGE	No. 372 Brannan Street.
JOHN E. PAGE	No. 372 Brannan Street.
CHAS. E. LIPP	No. 8 Liberty Street.
J. G. SMITH	No. 434 Fifth Street.
JOSEPH WALLACE	Fourth and Berry Streets.
HENRY WISSEL	Northeast corner Fourth and Berry Streets.
H. F. WISSEL	Northeast corner Fourth and Berry Streets.
THOMAS BLAIR	Fourth and Berry Streets.
PATRICK L. CURRAN	Northwest corner Fourth and Berry Streets.
JOSIAH FURBISH	No. 8 Howard Street.
NICK ZUCK	King and Fourth Streets.
J. E. ROBERTS	No. 554 Harrison Street.
E. B. RYAN	Room 6, Central Pacific Railroad Building.
F. STOLTE	Fourth and King Streets.
JOHN RATHERMAN	Fourth and King Streets.
B. S. STANLEY	No. 8 Liberty Street.
J. BULKLEY	No. 7 Crooks Street.
GEO. W. HOOPER	Fourth and Channel Streets.
A. BIENBERG	Long Bridge.
HINNRI PHILLIP	
J. H. HERLITZ	
RICHARD WELCH	Long Bridge.
JAMES MONSON	Long Bridge.
ROBERT ACKERMAN	Master of Schooner "Alfred."
FRANK F. LIBBY	Long Bridge.
CHAS. W. COLBY	St. Davids.
JAMES F. KELLY	St. Davids.
DAN. E. HOFFMAN	No. 715 Howard Street.
WM. J. PHILLIPS	No. 867 Market Street.
GEO. G. HINCKLEY	Fourth and Channel Streets.
J. P. RONNELLY	No. 11 Geary Street.
W. D. HENNESSY	No. 20 Fifth Street.
AMOS CUTTER	Long Bridge.
JAMES GALLAUDELETT	Long Bridge.
HENRY WHINFIELD	Long Bridge.
JOHN JAND	No. 851 Market Street.
JNO. CALDWELL	Bush and Sansome Streets.
JOHN DRYER	Corner of Fourth and Townsend Streets.
JOHN HARVEY	No. 117 Ellis Street.
F. COLEMAN	No. 7 Sherwood Place.
M. MENAGE	No. 1016 Taylor Street.
P. J. McCAFFERY	Second Street House.

C. M. CLAUDIANO—No. 246 Stevenson Street.
HENRY L. SUCCOR—No. 437 Mission Street.
JOHN KELLEY—No. 18 Minna Street.
ALLRICH VOLLERS—Fifteenth and Dolores Streets.
FRANK HERMAN—No. 19½ Freelon Street.
JOHN WALLS—No. 869 Market Street.
ADOLPH NOOTBAAR—No. 910 Market Street.
WILLIAM LEHRKE—No. 910 Market Street.
JAMES MARLIN—No. 102 Freelon Street.
BANKS DOBKING—No. 517 Mission Street.
WILLIAM WARDLAW—No. 964 Mission Street.
JAMES THOMPSON—San Francisco.
T. ZIMMERMANN—No. 22 Taylor Street.
J. W. HANNA—No. 1212 Mission Street.
WILL. TAYLOR—No. 565 Stevenson Street.
LOUIS BECKER—No. 257 Minna Street.
ANTONIO BELLAMORE—Corner of O'Farrell and Powell Streets.
THOMAS ALEXANDER—No. 223 Jessie Street.
JOSEPH BALLUFF—Corner of Fourth and Berry Streets.
ANDREW BUTLER—No. 629 Palace.
F. MERCIER—Mission Hotel.
W. OEHLMANN—No. 270 First Street.
A. WALLS—No. 539 California Street.
JAMES J. MOORE—No. 334 Seventh Street.
JOHN MAN—No. 441 Mission Street.
JOHN GRADY—No. 712 Howard Street.
JOHN MAIER—No. 7½ Deckman Place.
ORPHEUS McDULBEAE—Bryant Street.
FRED. SMITH—Mission Street.
JOHN McEINERTY—No. 867 Market Street.
JEREMIAH MURPHY—Long Bridge.
J. H. BAKER—No. 514 Chestnut Street.
SAMUEL R. VINCENT—Long Bridge.
THOMAS CROTTY—Long Bridge.
B. F. PINKHAM—Long Bridge.
CHARLES HURD—Long Bridge.
THOMAS LEDDEL—Long Bridge.
CHAS. H. HOLT—M. B. W. House.
A. A. POTTER—Long Bridge.
RICHARD SPECKLER—
C. G. BRUNDAGE—Mission Bay.
JAMES CHRISTY—
J. F. KENNEDY—
JOHN MAGER—No. 643 Third Street.
D. T. MUNSON—No. 104 Freelon Street.
JOHN WINTER—No. 607 Natoma Street.
WILLIAM MILTON—No. 14 Haggin Street.
ALFRED ROGERS—No. 454 Sixth Street.
A. BENNETT—No. 454 Sixth Street.
WM. LION—Corner Church and Dolan Streets.
JOHN ALVAN—
TIMOTHY COLLINS—No. 120 Berry Street.
JAMES A. FARRELL—No. 110 Berry Street.
JOHN MARTIN—No. 5 Drumm Street.
CHAS. H. MASON—No. 636 Commercial Street.

CHARLES H. FORD ---------- No. 137½ Clara Street.
HERBERT A. IRVING ---------- Cor. Kentucky and Merrimac Streets.
MAURICE SHEA ---------- No. 804 Third Street.
WILLIAM N. PECK ---------- No. 110 Third Street.
JOHN BROWN ---------- No. 804 Third Street.
EDDERT HEIKENS ---------- No. 804 Third Street.
A. DONOVAN ---------- Cor. Third and Berry Streets.
JOHN McCULLEY ---------- Alameda.
JOHN J. CONNICK ---------- San Francisco.
H. HAASE ---------- San Francisco.
H. PIERSON ---------- San Francisco.
JOSEPH GATES ---------- Cor. Mission and Twenty-second Streets.
JOHN CASSIDY ---------- No. 133 Folsom Street.
P. MOLOY ---------- No. 36 Rich Street.
JOHN TOHER ---------- No. 237 Main Street.
M. McDONALD ---------- No. 404 Folsom Street.
FRANK DOMNICK ---------- No. 16 Folsom Street.
JOHN SHEPIDE ---------- No. 16 Folsom Street.
CHARLES F. SHED ---------- No. 16 Folsom Street.
G. E. McMILLIN ----------
H. H. W. STROECKER ---------- No. 436 Fremont Street.
M. BRADY ---------- No. 351 Grove Street.
J. L. SICKLER ---------- No. 135 Second Street.
JOSEPH W. SMYTH ---------- No. 151 Tehama Street.

GENNARO SCOTTO,
GIOVANNI SPUTICH,
PETER NICOLS,
LUCA MARICEIP,
NICHOLOS SAMUK,
SALVATORE PONELLI,
MATTEO ROICH,
ARARETTO NORO,
PIETRO MARCHIANI,
GIOREPPE FOREATO,
PIETRO BESETTO,
GIOREPPE CARDILLO,
ANDREA BARAREOVICH,
PIETRO CARNIGLER,
GIO BATTA MORTALA,
FRANCISCO OLIVERI,
ANTONIO GHIO,
ANTONIO CARVIN,
PASQUALI ZOLERRI,
AGOSTINO GHIO,
AGOSTINO FALCONE,
GIACOME CUNICICK,
BATISTA ZALEZOZI,
LUIGI FERRECIO,
GIUSEPPE ANDREANO,
FORTUNOTO MAGGIO,
GIORGI DOBOVICH,
DOMENICO DI FRANCH,
BIAGIO SEAGIERLENDA,
CARLO ROSSI,
PALMIERI LOREZO,
GIACOMO CARNIGLIA,
ANDREA RAISH,
MAREO GIBOVICA,
LUIGI CARNESSI,
ROPERTO GAETANO,
F. DAPELO LUIGI,
FRANCISCO FORCADA,
COSTA GIUSEPPE,
JOSEPH PLETENCY,
GIOVANNO MARDESSIOG,
PETER KUEAVITZA,
NICOLA URDORICH,
SALVATORE LONGBARDO,
PIETRO MARSALS,
GEROLOMO BRIGANTE,
ROCCO CARACIOLO,
GIOVANNI GACINO,
MANOCLO SIACELULO,
GIOVANNO CARTAGNETTO,
GRECORIO CARTAGNETTO.
ANGELO BARDO,
AGASTINO NASSA,
CARMINO DI FRANK,
ABELARDO DEL VALLE,
POMATTEO BUDANOVICH,
GICCIOMO MARSICH,
ANTONIO SIMICA,
DAVID BALLERO,
CARMIGLIA GIUSEPPE,
ANTONIO SCIACHETANO,
G. MAGGIO,

COMASO BUDRONICK,
ANDREA CALARI,
GIOVANNI RADOVICH,
GIORGIO MILLICICH,
BAGGIO MANUEL,
GIOCOMO S. BISSI,
COSTA ARMANDO,
GIORGI CHICO,

GIANBATISTA DANERI,
CORNIGLIA STEFANO,
GIO BATISTA LOLEZZI,
BRUNO AGORTINO,
ANTONIO CAFFARANA,
D. GLOVER,
VINZENTE VARGELO.

THE

CULTURE OF THE GRAPE.

STATEMENTS OF PROFESSOR EUGENE HILGARD AND A. HARASZTHY

UPON THE WINE AND GRAPE INDUSTRIES OF THE STATE, MADE BEFORE THE COMMITTEE ON CULTURE AND IMPROVEMENT OF THE GRAPEVINE, FEBRUARY —, 1880.

WINE MAKING, GRAPE GROWING, DISEASES OF THE VINE,

THE BEST MEANS OF FOSTERING THE INDUSTRY.

THE PHYLLOXERA HERE AND IN FRANCE. THE BEST LAND FOR GRAPES.

THE FOOTHILLS FOR VINEYARDS.

The coming industry in California. The capabilities of the State.

LEGISLATION RECOMMENDED.

REPORT.

Pursuant to invitations issued by Honorable James Adams, Chairman of the Assembly Committee on the Culture of the Grapevine, a number of distinguished viticulturists were present at the meeting of that committee, held in the Golden Eagle Hotel, on Friday evening, January 30th. The meeting was called to order by Mr. Adams, who introduced its object, as follows:

Mr. ADAMS—Gentlemen, we have met this evening for the purpose of hearing suggestions looking to legislation for the promotion of the grape industry. I move that P. K. Stockton be elected Secretary, to take down the proceedings in shorthand.

Carried.

Mr. FELTON—Mr. Chairman, I think this is one of the important industries of the State that ought to be well taken care of.

Mr. DEL VALLE—Mr. Chairman, I will say, on behalf of this committee, that we have come to the conclusion that it is now about time that we should do something positive and definite in regard to the culture of the grape, and therefore we have concluded that we should do everything in our power to improve and foster this industry, which seems to be to-day the principal one of California; and, therefore, we have called upon those who are not only practical men, but who have made this matter the study of their lives, and I know that they can throw great light upon the subject.

Mr. HARASZTHY—Mr. Chairman, I would say, in continuation of the remarks of Mr. Del Valle, that now is about time that the State of California should feel some pride in this little infant that has been growing for twenty-five years—that has been struggling along unknown and unrecognized for a quarter of a century. Through its own qualities and its own merits it has finally found honor, if not in its own country, it has abroad. The English people take pride in sending across the waters at great expense, saying that in view of the ravages of the phylloxera in France, they will in future have to look either to their own colonies, or to California, for their champagnes and wines; and our heretofore neglected wines are coming to be known and recognized at home. They are good, and it is very strange that we have to look abroad for recognition. Now, each one of us wants to know what kind of vines we shall plant in order to make an income for our children.

Now, it has been through the struggles and exertions of a few men that this industry has not been heavily taxed. The Government of the United States has been very kind in not taxing it. The ravages of the phylloxera in France have caused a deficit or falling off of something like 700,000,000 gallons of wine. The German people are casting their eyes this way. Now, with 60,000 acres of grapes, how are we going to supply France and the civilized world with 500,000,000

gallons? No, sir; the only way is to go on and plant more vineyards. And if we plant new vineyards, we must have better education than we have had in the past. We have gone blindly to work and blindly planted everything we could get hold of in the way of vines. France prints volume after volume in the Government printing office containing valuable information, and these works are distributed among the people at the lowest possible price. They have all along followed out this policy. Now is the time for us to take up and follow out that policy. Last year we shipped away 169,000 gallons of brandy, every gallon of brandy representing five gallons of wine. We also shipped away 2,185,000 gallons of wine, and for these gold has been sent back—gold for us to spend, gold to clothe our wives and children, gold to decorate our homes and plant new vineyards.

France has laid the whole world under tribute for two hundred years for wines. Now we have in this State, the Surveyor-General says, 41,000,000 acres of land belonging to the United States. I say of that amount there are over 20,000,000 acres that are capable of producing wine. Twenty million acres producing wine, and the whole number of acres in France that did produce wine before the phylloxera began its work of destruction was only 7,000,000 acres, not capable of producing one-half as much wine as the same number of acres here would produce.

We have no severe frosts in this country. If a frost comes, it diminishes our crop only in part, five per cent., ten per cent., or thirty per cent., according to circumstances. In France they will have one frost after another, until the entire crop is destroyed. This is one of the many advantages possessed here.

Mr. MATHEWS—This land you speak of lies mostly in the foothills, does it not?

Mr. HARASZTHY—Yes, sir.

Mr. MATHEWS—Is it not a fact that they have earlier and heavier frosts in the foothills?

Mr. HARASZTHY—No, sir; it is just the reverse. There are lands on the sides of the mountains where goats would starve that will produce the best wines. The best lands in the State for vineyards have not yet been taken up, and they are to-day considered almost valueless.

Now there ought to be a certain amount of encouragement. The State ought to take steps, in an economical manner, to spread and diffuse the information that has been acquired, so that persons desiring to put money and time into the industry will not have to do it blindly. There are two plans, one of which is to have a place where you can go and have an analysis made of the soil, so you can have positive information given to you, and the question answered: "Is this a proper place for a vineyard or not?" Yesterday there was a gentleman came to me and said: "I have three hundred acres of land in Ventura County that I think of planting in vines. Now what grapes shall I plant to do well there?" That is a broad question. I asked him to describe the soil. "What kind of a climate is it?" "I don't know," said he. "Is it as cold as San Francisco?" "No." "As Sonoma?" "I don't know anything about Sonoma," said he. "As warm as Sacramento?" "I don't know; I think it is warmer than Sacramento."

I said: "You must not attempt to grow light wines there." But we must have the natural temperature to indicate what kind of wines

can be grown. We want the soils of every portion of the State analyzed, not by private individuals, but by the State institution. You have a State institution, and, at a very small cost added to their present facilities, they could take and carry on these analyses, without doubt giving the most true and complete knowledge as to the adaptability of certain grapes to certain soils—that is, at the State University.

Mr. ADAMS—How many acres of vines are there now in this State?

Mr. H.—The Surveyor-General puts it at 82,000 acres; I think that is too much by 20,000 acres. I cannot make it more than about 60,000 acres, or about 45,000,000 vines. Those are the figures of the Wine Growers' Association, as far as they are gathered. There may be fifty million vines, but I do not think there are.

Mr. ADAMS—How near can you arrive at the amount of wine made this year?

Mr. H.—I have reckoned it up in the report I made as President of the Wine Growers' Association; I think there was a little more than I figured on, 6,000,000 gallons of wine. I have seen it reported as low as 4,000,000, but I can show you where 6,000,000 gallons are. For our brandy there is a very active demand. There will be over 320,000 gallons made in the State for this fiscal year. Our people ought to have produced at least 10,000,0000 gallons, and that amount will be produced next year. If the frost does not injure the crop, we will produce at least 10,000,000 gallons of wine and 500,000 gallons of brandy, not including grapes for consumption and those used for raisins.

Mr. ADAMS—How many raisins were made in the State last year?

Mr. H.—I have no means of knowing the amount.

Mr. MATHEWS—What was the value of the wine product?

Mr. H.—I think it was 1,400,000 gallons of wine we shipped away in 1879, and I think the valuation of the brandy was about $300,000. That does not include the shipments to Arizona. I tried to get it, but could not. The other shipments I have got exactly. There were some 300,000 gallons entered the Bay of San Francisco, and 3,400,000 gallons entered the port by rail. The railroad took east 716,000 gallons of wine. That pays a nice little sum. The beauty of the industry is that it does not interfere with grain raising. It does not lessen the area of grain at all, and does not take any land that is good for anything else.

Mr. CAMRON—Is it not a fact that this State is capable of producing more revenue in the way of wines than in grain?

Mr. H.—Undoubtedly so, sir. I would not like to give the figures, because the amount is so enormous as to be almost beyond belief.

Mr. CAMRON—Isn't it a fact that in some parts of Europe they have to make the soil?

Mr. H.—In some parts of Germany they do, and in some parts of France. On the Rhone there are very steep grades—that is, in the western part In the southern part it is all flat. In the western part the mountains are steep. Right above Bingen on the Rhine the hills are terraced.

Mr. FELTON—Can you give us the number of acres planted and now in bearing, and the production, and the number of acres planted to come in, in the different counties?

Mr. H.—I refer you to the reports of the Surveyor General; I haven't them here. Diminish his figures by 25 per cent., and you will arrive at about the exact figures. Our Association has all the figures in relation to this matter.

Mr. FELTON—Are they not more reliable than those of the Surveyor General?

Mr. H.—Yes, sir, because we come in contact with all the people who are interested. We have societies throughout the State; have records which may not be perfect entirely, but they are very close estimates; therefore you could rely upon them. The suggestion I was going to make was in reference to making analyses of soil. I have found that the same variety of grapes take on a different nature in different localities. A gentleman at the Mission San José showed me recently a sample of wine which he said was made from the Zinfindal grape. I did not want to believe him, but he asserted it positively. I thought he had made a mistake, or he had been imposed upon, but he insisted upon an investigation. I knew he did not want to play any tricks. I went out and saw the vines, and then I recognized the vines as being Zinfindal. That showed that an entirely different wine may be produced from the same vine on different soils. When I came to look at the soil I found it was entirely different from any I had examined. Now these things should all be put upon record in some reliable manner. That is why it is essentially necessary that this thing should be done by the State. A man wants to plant a vineyard, for instance. He has a piece of rocky land, and he wants to know how and what to plant. My idea was to educate the young people, so that the rising generation may know how to utilize the land. If a man has been educated at the University after this experimental department has been established, he would know at once how to utilize any barren land to the best advantage. The waste land of the State which cannot be utilized for any other purpose can be made available for this purpose.

Mr. MATHEWS—Don't vines require irrigation?

Mr. H.—No, sir; you will spoil them if you do. They are a great deal better without.

Mr. MATHEWS—That is contrary to my experience, dan I have known vines to die outright without irrigation.

Mr. H.—I had a talk recently with a gentleman from your county (Tehama), I bought his wine, and he told me that he had not irrigated his vines since the first year.

Mr. MATHEWS—I know that he does not; but if they cannot be made to grow without water what is to be done?

Mr. H.—They can be made to grow without water. Mr. L. J. Rose, of Los Angeles, one of the largest wine growers of that section, has planted and grown vines for the last twenty years, and has irrigated all along. Now he has come to the conclusion that his work in that direction has been thrown away. He has planted 300 acres of vines on flat, sandy land, and was laughed at by his neighbors, but he has found that they do just as well without water. His place is near San Gabriel, east of Los Angeles.

Mr. MATHEWS—How does that climate compare with the climate of the Sacramento Valley?

Mr. H.—The climate of the Sacramento Valley is not much hotter than that of the San Gabriel Valley. They plant vines at Woodland, and they grow without irrigation.

Mr. MATHEWS—The gentleman spoken of in Tehama County has rich bottom land where there is no need of any irrigation.

Mr. H.—He told me that he thought vines grew better if irrigated the first year. I asked him if he had ever tried the other plan and he said not.

Mr. FELTON—Don't you think the depth of the soil has much to do with that question?

Mr. H.—The depth of the soil has a great deal to do with the productiveness of the vines, but sixteen or eighteen inches of soil is enough. Grapes do not require a deep soil. Of course the deeper the soil the more grapes will be produced. But a vine will grow and produce in six inches of soil. The Buena Vista Vineyard, in Sonoma County, where the vines were planted in 1837, and have not been irrigated since 1856—my father first planted out a vineyard there on dry soil. There was no means of irrigation It was on the hillside, on land so poor that it would not grow grain.

Mr. ADAMS—What are the prices paid for the season's wine crop?

Mr. H.—Prices have varied. But there is a very striking contrast between the prices now and those which prevailed several years ago. I have bought Mission wines in round quantities, of last vintage, from 21 to 21½ cents per gallon at the cellars. For Zinfindal I have paid as high as 36 cents per gallon, in large quantities. I have bought other varieties at 25 cents. I suppose the average price of dry wines is about 30 cents at the cellars. This does not include sweet wines. For brandy I have paid 90 cents at the distilleries, exclusive of the Government tax. That is about the price paid this season. In 1876 you could have bought brandy at 37 to 40 cents, and wine in any quantity at 10 to 15 cents per gallon. Those were the dark days.

Mr. MATHEWS—Have you any information as to whether the phylloxera is less liable to attack the grapevines here than in France?

Mr. H.—The phylloxera is limited to Sonoma Valley, and to certain portions of Fresno County. I have not made a study of it as Professor Hilgard has, but I believe that it is not so apt to attack our vines because our soil is richer. Some vines are less liable to attack than others. We have found some vines that they leave until all others have been destroyed.

Mr. MATHEWS—That is a question for the College to determine?

Mr. H.—Yes, sir; there ought to be an experimental station in southern California, say in Los Angeles County, and one in the northern part, say in Sonoma, Sacramento, or Napa. I think that is premature, however, because this plan would be very costly. But the suggestions we urge could be carried out for the present at a very moderate cost.

Mr. MATHEWS—Do you think it will be necessary to buy the land?

Mr. H.—No, sir; all that would be necessary is a certain small sum to enable the society to organize and have a Secretary, for printing and for disseminating the information gathered by the society, incorporated as a State institution; that will supply all that is needed as present, as far as this society goes. All that is necessary is a small appropriation to enable the society to maintain an office, to have a Secretary, and to do certain printing. Then a small appropriation for the State University, to enable them to make analyses, and to

make certain improvements, and to provide the necessary facilities for carrying on the work. The sum asked is very moderate. Now, the phylloxera in Sonoma has destroyed about 800 acres of vineyard. The taxation on that is something like $3,000 a year. Now, if you could find the means to stop the ravages, at the end of four years you would have saved $12,000. Thus you would save more money than this appropriation calls for on this 800 acres.

Mr. YOUNG—About what amount would you suggest to be proper in this matter?

Mr. H.—I think for the next two years something in the neighborhood of $6,000 for each year. Now the vineyards are paying an income to the State of something like $240,000. That is making a very slight return for the income they bring to the State.

Mr. YOUNG—What would you suggest further that this Legislature ought to do?

Mr. H.—That is all. These experiments would be quite complete. It comprises a series of lectures on wine making right in the center of the different wine districts. You can very easily get an audience to listen to a lecture when the lecture is delivered at their homes, when the same people would not go to San Francisco for the purpose of hearing the same lecture. Such a course of lectures is contemplated.

[Mr. Haraszthy here exhibited volumes of the French Agricultural Reports, showing the subjects treated.] There they have a regular course. We have no such thing here.

Mr. ADAMS—You are aware that the vine disease is confined to a small locality around the town of Sonoma, and that the Sonoma Valley is a very small part of Sonoma County?

Mr. H.—Yes, sir, I am aware of that fact.

Mr. MATHEWS—How did this insect get here?

Mr. H.—Professor Riley says he has known of the existence of the phylloxera in this country for forty years; that is, in Missouri. In Sonoma, before the introduction of foreign cuttings, there was no indication of the phylloxera. They are supposed to have been introduced with imported cuttings.

Mr. ADAMS—It has been proved that the insect will not cross a road between two vineyards.

Mr. H.—It has been proved that a vineyard one side of a road is affected, while on the other side the vineyard is entirely free from them.

Mr. ADAMS—Have you any suggestions to make about the duty on French wines?

Mr. HARASZTHY—I have noticed that some of the newspapers are greatly elated on account of the great diminution of the product of the French wine crop. Now, I do not see it at all. Because it seems that the smaller the French crop is the more wine they make. If the grape crop fails, the beet crop answers the purpose, and their mountain springs do not dry up, and the supply of sulphuric acid and alum is not yet exhausted. France herself is a large importer of wines. She imports 40,000,000 gallons of wines. I have in my possession some French labels which I might show you, but I won't. Some gentlemen think it is a great thing to have French labels on the wine they drink. There is a great deal of that thing done. These are people of very fine imagination. If this treaty should pass France would become an extensive exporter of wines. She would

bring the wines of Hungary, the Grecian Archipelago, and the wines of the entire country of Italy, the wines of Spain and Portugal, mix them, and send them to us. They would play second fiddle, as it were. She could deliver these manufactured wines so cheaply that we could not compete. This would be a very serious mistake to make. Nor would it be the cause of the people getting their wine any cheaper. We would pay just as much for our wines. The consumer is not benefited in the least, but the middleman reaps all the benefits. I made some statistics from the books of the Custom-house, and I have found that the average price of French wine during the past ten years, in the port of San Francisco, has been thirty-two cents in casks, and sixty-four cents in bottles. During the same period the average price of this fine old French brandy that you and I have paid $10 a gallon for, in the port of San Francisco, was $1 61 per gallon. That is the price delivered here. You and I have paid big prices for it. Looking over the statistics, I find that last year there were more gallons of brandy brought here from England, by 500 gallons, than came from France. There was twice the amount of Port wine came from France than from Portugal into our port. I found that there was just as much Sherry coming from France as from Spain. Now, how does that come? I have also found a large amount of wine coming from Scotland. I do not know how it grew there. When we look at these things, it is about time for us to look at home. Now we use about 1,000,000 gallons of native wine a year. Who is it drinks this wine? Americans? No. The Germans drink some, but very little. But the French, Italians, and Portuguese drink it, and grow fat upon it. They laugh at us, and say we don't know what is good. They say the wine is a great deal better than the wines made in their own country. You can't go into any fisherman's hut in San Francisco without finding a sixty-gallon cask of claret that he has made or bought. You will see them all drinking California wines, but you will never see any drunkards among them.

Now, I have heard it said that there are no native wines drank in the United States. That is a mistake. Our exports last year amounted to 2,000,000 gallons.

Prof. HILGARD—Mr. Chairman, it is hardly necessary to add anything to what has been said as to the importance of this subject. Five years ago the industry was at a very low ebb; but things have assumed a very different aspect. In the first place, something of this change is due to the misfortunes of our neighbors. The phylloxera has seriously diminished the wine production of France. That country is looking to us to make up that deficiency. Our wines are fast obtaining a reputation at home and abroad. Experienced men have taken hold of the industry. The men who were educated in wine growing in Europe will have to learn the lesson over again in this country. The conditions here are different. Considering the fact that we have five different wine making nations represented in this State, it is really a wonder that so much good wine has been made. Each one proceeded to make wine according to his own method. The German has attempted to make Rhine wine from the Mission grape, and others the same in regard to other wines. Considering these facts, it is remarkable that so much good wine has been made. The Mission grape was the first grape planted in the

country, but it is a poor grape, I am sorry to say. It is the poorest grape we could have, except as to its quantity.

Now, it has always been my conviction, and I have carried out that idea as a teacher, that what the farmers needed was not so much that their sons should go the University, as that the farmers themselves should be taught in regard to these matters. I have been confirmed in that conviction. I have attempted to establish an agricultural college on the so-called Davis system. For two years we waited for students and none came. I am thoroughly satisfied that experimental stations are the only means by which we can promote the welfare of the agricultural world, similar to those in the Old World. We want to do something for the improvement of the wine industry of the State. With what Mr. Haraszthy has said I must heartily agree. My experience is that the foothills comprise the best wine growing lands in the State. I have seen the exact reproduction of the soils of the old country. Now, what can we do to promote this industry?

Now, in regard to the means of the University, I wish to say this: When I first came here I became satisfied that I must have an analytical department. The first year I had my pick of work; now I have an immense amount of work on hand; I am so crowded that I don't know where to begin; the means are not adequate to the work on hand. While the appliances are nearly complete, it is necessary to have additional force in order to enable us to carry on practical experiments. We need a cellar where we can maintain a uniform temperature in making experiments in fermentation. We can compare the grapes growing on different soils with one another; see which produces the best grapes for certain kinds of wine. In regard to the experiments in grape growing, the climate of Berkeley is not adapted, except for propagation. There are certain varieties which resist the phylloxera, others do not. In regard to experiments in grape growing, they must be carried on where grapes grow. We ought to have at least four experimental stations in different parts of California. In Europe these experiments are made on land owned by the Government, and the entire expense is paid by the Government. We have no Government land, and the management by the State is something not in exact accord with our ideas; but as far as experiments are concerned we have received most liberal offers from individuals who are willing to coöperate in making them, and at no greater expense than simply a trifling outlay for labor and material. The most important thing to be done, as far as the University is concerned, is to make an appropriation to enable me to carry out the work, also to enable us to maintain a cellar at the institution in which experiments in fermentation can be carried on; to enable us also to go to the places where other experiments are being carried on for the purpose of superintending them. Therefore, a certain amount of traveling expenses ought to be provided for.

Mr. CAMRON—About how much do you think you would need?

Mr. H.—About $4,000 for two years. There are two kinds of experiments to be made; the practical experiments can only be made at the vineyards; the scientific experiments must be carried on at the University; the latter require constant supervision and constant watching; it is not like practical experiments, this can be done only on a small scale. I understand that lands for the stations in different parts of the State can be had free. I have found

that grapes of different degrees of ripeness produce different wines, or different flavor. These things must be critically tested, and grapes brought to the University which have been picked at different times.

Brief addresses were made by Messrs. Krug, Larue, and others, indorsing the views expressed by the principal speakers, and the committee adjourned to make a practical test of some very choice native wines furnished by the Chairman.

Mr. KRUG—Mr. Chairman, there is but little remaining to be said. I think we need some assistance by the State. We have had a long hard struggle for the last twenty-four years; now it is beginning to be acknowledged that we can make wine. But what we want now is assistance to aid us in spreading information. These gentlemen have made a calculation as to the assistance needed, and I can only repeat what they have said. I think the University needs something in the neighborhood of $2,000 to carry on its experiments and to furnish lecturers to deliver lectures in different parts of the State. We need between three and four thousand dollars. With this amount we can accomplish what we have mapped out to do. The business of wine making is progressing rapidly. If you take into consideration that every acre brings from fifty to one hundred dollars clear profit, and that good wheat land does not bring more than ten or fifteen per cent. profit, you will, perhaps, think it is worth while to give us a few dollars to foster and encourage such an industry. When we plant 2,000 acres in vines, as we shall do in our valley, it is reclaiming and bringing that much land into bearing, increasing its value immensely. For the few dollars you give us, you will get hundreds of thousands back in the shape of increased taxes. It is only a small outlay, but you will be richly repaid. We want to spread knowledge on the subject, and it is for that purpose that we ask this appropriation.

Mr. LEACH—I would suggest that these gentlemen reduce their desires to writing, and submit it to the committee, for when they come to make up the appropriation they will ask us what this money is to be used for. I do not think there will be any difficulty in getting this amount of money.

Prof. HILGARD—Mr. Chairman, I neglected to say anything about the phylloxera. When I first came to this State the phylloxera was limited within a district of two miles. It has since spread over a space of ten or eleven miles, and it threatens to advance from Sonoma Valley until it spreads out over the whole State. I have kept a close watch over it, and I say that we are in very great danger from it. For some cause the progress of the insect is very much slower here than in other countries; instead of jumping fifty miles in one season, it has made steady and slow progress from half a mile to a mile in a year. I interpret that as a sign that the insect fails to go through one of its transformations into the winged form.

Mr. MATHEWS—Some claim that the Sacramento Valley is not favorable to insect life. What is your experience?

Mr. HILGARD—I have never heard of this insect here. This insect goes through five generations in the course of the year. The fifth generation has wings, and they rise into the air and are carried broadcast by the wind. This they do not do in California, and that accounts for the slow progress. Speaking of insects in the Sacramento Valley, there is great trouble by the coddling moth here.

Mr. YOUNG—Where does the phylloxera attack the vines?

Prof. HILGARD—At the roots. They consume the juice of the vines, attacking the white rootlets.

Mr. MATHEWS—Have the French ever found any remedy for it?

Prof. HILGARD—They have found a remedy which can be made there very cheaply. This costs 60 cents per pound here, but in France it can be sold for 2½ cents. We have thousands of tons of the raw material. We have used it very successfully at the University grounds for poisoning squirrels. A good many have tried it and found it to do the work, but at 60 cents a pound they cannot afford to use it very extensively. If it could be had for about five cents per pound it could be brought into general use. The two materials from which it is made are sulphur and charcoal. We have extensive deposits of sulphur in this State, and it ought to be made very cheaply. The liquid is exceedingly volatile, and when you pour a little of it into the hand it almost flashes into vapor. But it endures long enough to kill the squirrels. They are using it in France now, and some of the most celebrated vineyards are being preserved by this means.

H. M. LARUE—Mr. Chairman, I came here as a listener. While I do not represent that particular branch of agriculture, at the same time I feel a very great interest in it. I am satisfied that the State cannot appropriate money to a better purpose than to foster the great industrial interests of the State. That is our chief dependence to-day. I am very glad to observe the liberal spirit manifested by the committee. The vinicultural interest is a great interest in the State to-day. It is the coming industry. It is only a question of a few years when it will be the leading industry. I did not come here to advocate the claims of the State Agricultural Society, but I wish simply to call the attention of this committee to the fact that we ask the Legislature to make an appropriation this year. Money invested in this way is money well expended, and we hope that this Legislature will be liberal with the various agricultural societies throughout the State, and especially the State Society. It is a question as to how we shall get at this appropriation. We hope to mature some plan and present it.

I. N. HOAG—Mr. Chairman, I have been in such position as that it was to my interest to favor the protection of these industries. I have been the Secretary of this Vinicultural Association; in fact, I was in it at the birth; I helped to get the first appropriation through. I was Secretary some three years, while I was Corresponding Secretary of the State Society, and I have always been known as a solicitor of liberal premiums towards all these industrial institutions, from their inception. I, like one of the members here, have always labored to have the State receive an equivalent for its appropriations. I think the vinicultural interest is one that requires at the hands of the State liberal appropriations, because the interests connected with it are in a measure new, and now there is a prospect that value will be received for every dollar paid out. In addition to the encouragement of this industry you have other agricultural industries to be fostered. In regard to the general industries of agriculture, I don't know whether it will be better for the Legislature to combine all these industries under one head, put them under one management, or whether it will be best to divide them up

and give each one a separate head. Now, in the old governments, I believe it was customary to put everything under Commissioners of the Government. That is the policy of our general government. Our State Society is organized as a State institution. I believe it is not prohibited by the Constitution from receiving State appropriations. There is no prohibition against the Legislature appropriating money to corporations and associations that are exclusively under the control and management of the State. That prohibition does not apply to the State Agricultural Society. The Vinicultural Society is subject to prohibition as it at present stands. You propose, however, to put it under the control of the State. If the State Agricultural Society is not in that position it is our desire to have it so placed. And if not so placed, to put it in a position where it can receive benefits; to set apart certain funds that shall go every year for the benefit of the State Agricultural Society, in regard to the licensing of stock.

The committee adjourned to meet at the call of the Chairman.

REPORT

OF THE

JOINT STATE PRISON COMMITTEE

ON THE

Construction of the Branch Prison at Folsom.

REPORT.

State Capitol, March, 1880.

To the Honorable Senate and Assembly of the State of California:

The undersigned, members of the Joint State Prison Committee, beg leave to respectfully present the following report:

The first legislation upon the subject of a Branch Prison was by the Act of April 24th, 1858, entitled "An Act for the government of the State Prison convicts, and to provide for the location of a Branch Prison." This Act first created the Board of State Prison Directors, composed of the Governor, Lieutenant Governor, and Secretary of State. The sixth, seventh, and eight sections of the Act are as follows:

Section 6. The Board of Directors are hereby empowered to select a suitable place for the location of a branch of the State Prison; and when such location shall be made, and it shall be on the property of any private citizen, the Board shall purchase the same and cause a good and sufficient deed thereof to be made to the State.

Sec. 7. Whenever a site shall be chosen for a Branch Prison, as provided for in this Act, and the property shall be duly conveyed to the State, the Board shall, as soon as practicable, cause such a number of convicts as they may deem proper, first selecting those whose term of imprisonment is about to expire, to be removed from the State Prison at San Quentin to the said branch site.

Sec. 8. The convicts removed to the Branch Prison pursuant to this Act, shall be given in charge of such officers as the Board may appoint for that purpose, and shall be subject to the general rules and regulations adopted for the government of the State Prison convicts.

The Legislature had at the same session, prior to this time, by the Act of February 28th, 1858, directed the Governor "to take immediate possession of the State Prison and grounds, together with all the property of the State therein situated, and to assume the custody, control, and management of the State Prison convicts therein confined, or to be confined therein."

By the Act of March 21st, 1856, a Board of State Prison Commissioners had been created composed of the Lieutenant Governor, Controller, and Treasurer, with authority "to lease the State Prison grounds and property, together with the convict labor of this State, for a period of five years, at a price not to exceed fifteen thousand dollars per month."

On the 26th of March of that year (1856), a contract was let under

the provisions of that Act to James M. Estill, by which the State undertook to pay the contractor ten thousand dollars per month.

By the two Acts of 1858, above referred to, this contract was abrogated, and subsequently, by the Act of April 30th, 1860, the State settled the claims of the assignees of the contractor with an appropriation of two hundred and seventy-five thousand dollars.

The Board of Prison Directors were wholly dependent upon the general appropriations made for the support of the State Prison, in order to enable them to carry into effect the provisions of the Act of 1858, above quoted, and these general appropriations were never more than sufficient, and were quite often insufficient to meet the rapidly increasing demands of the prison at San Quentin. No special appropriations were made for the Branch Prison until 1874 and 1878, which will be hereafter referred to.

From and inclusive of 1858, until and inclusive of 1878, the following appropriations were made for the support of the State Prison, not counting those made in 1874 and 1878 for the erection of the Branch Prison:

1858—For support	$75,000
1859—For support	75,000
" For transportation of prisoners	25,000
" For deficiency in transportation of prisoners	25,000
1860—For support	75,000
" To settle with assignees of Jas. M. Estill	275,000
" For transportation of prisoners	25,000
1861—For support	50,000
" Purchase of additional lands	12,000
" Transportation of prisoners	25,000
1862—Support	50,000
" Deficiency in support	10,000
1863—Support	50,000
" Transportation of prisoners	25,000
" Deficiency in transportation	25,000
1864—Support	100,000
" Transportation	50,000
1866—Support	100,000
" Deficiency in support	35,000
" Transportation	50,000
" Construction of cells	10,432
1868—Support	100,000
" Deficiency in support	60,000
" Transportation	30,000
1870—Support	200,000
" Deficiency in support	58,410
" Transportation	40,000
" Deficiency in transportation	7,000
1872—Support	200,000
" Deficiency in support	40,000
" Transportation	40,000
1874—Support	200,000
" Deficiency in support	25,000
" Transportation	45,000
1876—Support	240,000
" Deficiency in support	42,000
" Deficiency in support	24,000
" For new work shops, machinery, etc.	200,000
" Transportation	50,000
" Deficiency in transportation	6,000
1878—Support	300,000
" Deficiency in support	110,000
" Transportation	55,000
" Deficiency in transportation	2,248
Total	$3,242,090

From 1858 to 1868 nothing was done by the Prison Directors towards locating a Branch Prison, pursuant to the provisions of the sixth, seventh, and eighth sections of the Act of 1858.

It will be readily seen from an examination of the foregoing table of appropriations that they were not furnished by the Legislature with the means to do so.

The next action taken by the Legislature was the Act of March 30th, 1868, entitled "An Act supplemental to an Act entitled an Act for the government of the State Prison convicts, and to provide for the location of a Branch Prison," approved April 24th, 1858, which Act consisted of a single section, which was as follows:

SECTION 1. It shall be the duty of the Board of State Prison Directors of this State, on or before the 1st day of July, 1868, to make the selection and location of the site for a Branch Prison, and to cause a good and sufficient deed of the land so selected to be made to the State of California as provided for in section six of the Act to which this is supplemental. Said site and location shall be made either in the Town of Rocklin, in Placer County, or on the lands offered to the State by the Natoma Water and Mining Company, in Granite Township, Sacramento County, as said Board shall determine, selecting between those sites the place which offer the greatest advantages for prison purposes.

The Prison Directors acted under this law, examined both the sites mentioned in the Act, and selected that at Folsom.

On the 30th of June, 1868, they took from the Natoma Water and Mining Company a deed conveying to the State 350 acres of land, with extensive granite quarries thereon, for the consideration of $15,000, to be paid in prison labor at fifty cents per day; said labor to be used when the prison should be completed, in the excavation of a large water power canal which the company was then, and for some time before, had been engaged in constructing.

There was a provision in the deed that the State should have at the prison site a water power from the canal equal to the whole power of the canal with a perpendicular fall of five feet.

Subsequently, on the 3d of June, 1874, the company, at the request of the Directors, conveyed to the State an additional tract of 133 acres adjoining the one first conveyed, without any additional consideration.

The whole subject of establishing a Branch Prison at Folsom was frequently considered and investigated by committees of the Legislature.

In 1874 the Joint State Prison Committee—Honorable J. H. Neff being Chairman of the Senate Committee, and Honorable Thomas J. Ables Chairman of the Assembly Committee—thoroughly investigated the prison at San Quentin and the proposed Branch at Folsom, and examined and considered all questions bearing upon the subjects.

Their interesting and valuable report, consisting, with the testimony taken, of 91 printed pages, was, by some mishap or other cause, omitted from the appendixes to the Senate and Assembly Journals of that year.

We have, however, been favored with an official copy of the report.

The committee held nineteen meetings and examined thirty-seven witnesses.

At that time San Quentin had 941 prisoners, for whose accommodation there were 444 cells and eight rooms.

We take the following statement from this report:

"The following table gives the cubic feet to each man at the present time (February, 1874):

Number in bedroom, 35; cubic feet per man	135
Number in Room B, 44; cubic feet per man	194
Number in Room 1, 14; cubic feet per man	142
Number in Room 2, 39; cubic feet per man	121
Number in Room 3, 45; cubic feet per man	105
Number in Room 4, 45; cubic feet per man	105
Number in Room 5, 39; cubic feet per man	121
Number in Room 6, 45; cubic feet per man	105
Number in 14 double cells, 56; cubic feet per man	116
Number in 34 double cells, 102; cubic feet per man	155
Number in 65 single cells, 130; cubic feet per man	139
Number in 331 single cells, 331; cubic feet per man	279

"This is indeed a most deplorable state of affairs, and in direct violation of all the established laws of physiology and hygiene, which require that a healthy man should have at the very least 500 cubic feet of ventilated space. Aside from the fact of the great lack of sleeping capacity in these buildings is also to be deplored the unguarded practice of commingling all ages and classes together, resulting in the propagation of secret and degrading vices, thereby making the prison a hot-bed of evil, and deteriorating the ends for which prisons have been established. By such a pernicious state of affairs, the young and uninitiated convict is compelled to associate with the old and hardened ones, who, in a short companionship, shape out the otherwise susceptibility to moral improvement beyond redemption, and in reality verify the phrase that 'evil communications corrupt good morals.' This system of packing or crowding so many human beings in such small space should be stopped as soon as possible, and no cell should be occupied by more than two prisoners at most."

The 444 cells above described contain 132,750 cubic feet of air, being 298 feet in each cell. The 324 cells in the new Branch Prison contain 155,520 feet, being 480 feet in each cell.

After a full consideration of the subject, this joint committee of 1874, consisting of thirteen members, adopted, by a vote of nine to four, the following resolution:

Resolved, That it is the opinion of this committee that the interests of the State and society will be served by the establishment of a Branch State Prison.

And by the same vote adopted a resolution in favor of establishing such Branch Prison on the site near Folsom.

The same Legislature authorized the commencement of the construction of the prison, and appropriated the sum of $175,000 for that purpose.

Since 1874, the cell room at San Quentin has been increased by the addition of 204 single and 48 double iron tanks (cells), so that there are now 696 cells and tanks; but this has not resulted in any increase in the breathing space for the convicts. The increase in the number of convicts has been greater in proportion than the increase of the

cell accommodation. On the 1st of July, 1879, according to the official report of the Warden, there were 1,564 convicts at San Quentin. In reference to this overcrowded condition of these convicts, Lieutenant-Governor Johnson, the Warden, in the same report said:

"Still we have made many reforms in the last two years, and, but for a defection in the cell buildings, and want of room, would have to-day exactly the present New York system. To enable us to adopt that system entirely, we must have cell room sufficient to prevent the doubling up of prisoners. Each prisoner must have his separate cell, and the law must authorize his confinement therein for a time at least, with or without work, when he first enters, or at any other time for that matter, at the discretion of the management. * * * As soon as the Folsom Prison is opened, which may be at any time after the first of January next, a trifling outlay of money will prepare the necessary room to place each prisoner in a cell to himself. When we have accomplished so much, and inaugurated the new system, which we may do by transferring 500 prisoners to the new Penitentiary at Folsom, ours may then rank among the highest and best institutions for the suppression of crime and the reformation of criminals."

In regard to the unavoidable promiscuous association of convicts at San Quentin, the Warden in the same report remarks:

"This sort of association here is doubtless the cause of hundreds of returns to the prison, and of course of the commission of hundreds of crimes. In a recent communication of a committee of the Howards (Howards Association of England), to the Home Secretary, I find these remarks: 'The due separation of prisoners from each other only is an essential feature of a wise and efficient treatment; but mere solitude is unnatural and pernicious. It is neither wise nor merciful. Prisoners, when separated from evil companionship, should be necessarily brought under the influence of good intercourse, both from within and without.' In this short paragraph lays the foundation of the best economy, the most humane treatment of convicts, and the best repressive and reformatory methods possible at any penitentiary. These principles may be carried out here after the new prison is opened, and the number here reduced to 1,000, by an outlay not to exceed $10,000, in enlarging the cell room."

As before stated, the Legislature made the first appropriation of $175,000 for building the Branch Prison at Folsom, in 1874. A plan for the prison building was adopted, and a contract let for the erection of a portion of the prison, to embrace 168 cells. This contract was let to Michael Miles, who was the lowest bidder, for the sum of $149,000. This contractor, after doing a portion of the work, without, however, completing any of the cells—the most costly portion of the work—abandoned his contract in September, 1875. He had been paid something over $79,000, which was eighty per cent. of the amount of work he claimed to have done.

The State subsequently became involved in a litigation with one Holmes, an assignee of Miles, in which Holmes recovered a judgment against the State of about $34,000. This case is now in the Supreme Court, on appeal by the State. As to the merits of this controversy,

the committee are not sufficiently advised to express any opinion. It is sufficient to say that we are informed that it is the opinion of the attorneys representing the State, that the judgment will be reversed on the merits of the case.

No additional appropriation was made to continue the work by the Legislature of 1875-6. The Assembly Committee on Public Buildings and Grounds, Hon. G. N. Cornwell, Chairman, examined the subject of the Branch Prison, and the work under the Miles contract, and strongly recommended the continuation of the work upon a modified and less expensive plan. The committee summed up its report with the following recommendations:

"*First*—That the disposition of the whole Branch Prison matter be turned over to the Board of State Prison Directors, and that they be authorized and instructed by the Legislature to make a fair trial to see whether the building can be advantageously finished as above set forth, and if it can be so finished, to go on and complete the work.

"*Second*—That said Board be further authorized to make such terms with the contractor as in their opinion may be of benefit to the State for the purchase of the materials already on the ground, and for the completion of the work.

"*Third*—That there being in the State treasury $85,694 73 to the credit of the Branch State Prison Fund, a further sum of $30,000 be appropriated to carry on the work on the Branch State Prison, or such other sum as may, on examination, be found adequate for that purpose."

No Act was passed by the Legislature of 1875-76, upon the subject of the Branch Prison. The reason for this inaction may probably be found in the fact that while the Legislature was in session the work shops at San Quentin were destroyed by fire, and it was thought necessary to appropriate $200,000 for their immediate reconstruction. This, with $362,000 appropriated for that prison at the same session, making an aggregate of $562,000, was felt to be a sufficient demand upon the resources of the treasury for prison purposes at that time. Besides, it was yet undetermined as to what action would be taken by the State in the matter of the Miles contract.

This brings the history of the State prisons to 1878.

The Assembly Committee on State Prison and State Prison Buildings, Hon. John H. Miller, Chairman, made two reports, one upon the prison at San Quentin, and one upon the branch prison at Folsom.

The Senate Committee, Hon. Paul Shirley, Chairman, also made a report, from which it appeared that there were then 1,402 convicts at San Quentin, and that the 204 new single tanks were crowded with 393 prisoners. These tanks are each five and one-half feet wide, eight feet long, and seven feet ten inches high, and contain, without allowing anything for obstruction, 345 cubic feet of air each. With two men in a cell and an allowance of sixty feet for obstruction, it will be seen that each convict had only 143 feet of breathing space.

There were forty-eight new double tanks, so called, which were seven and one-half feet wide, eleven and one-half feet long, and eight feet high, and contained 660 feet each, into which were crowded 140 prisoners.

From all these reports the necessity for the early completion of the Branch Prison appeared more apparent than ever.

The special report of the Assembly Committee in relation to the Prison at Folsom strongly urged the immediate completion of the work. This report may be found in the fourth Appendix to the Journals of the Senate and Assembly of the twenty-second session, and is an interesting and valuable document at this time, as it satisfactorily shows that the Branch Prison can be made a self-supporting institution, and at the same time a means of reformation and improvement in the moral well-being of its inmates.

It was found that much of the building as originally planned was of an unnecessarily expensive character. The committee procured the services of A. A. Bennett, an architect of acknowledged ability and large experience in that kind of work, to prepare plans and modifications for the finishing of the prison at a less cost than the original plans required. These plans and modifications were furnished, and covered the completion of the building upon the general plan originally contemplated with 328 cells.

The Legislature of 1877–8, by the Act of April 1st, 1878, appropriated the sum of $120,000, and reappropriated the sum of $85,494 73 (being the amount remaining unexpended of the $175,000 appropriation of 1874), making an aggregate of $205,494 73, for the completion of the prison.

The Act provided "that the State Prison Directors, if in their judgment it is advisable, and will better conserve the interests of the State, are hereby authorized to adopt the plans and specifications submitted to the committee by A. A. Bennett, in relation to said Branch Prison, and may, at their discretion, contract for the completion of the two first sections of said prison."

One of the leading arguments in favor of the bill in the Senate was, that the prisoners could be profitably employed in the granite quarries upon the lands of the State in close proximity to the prison. This was doubted by those who opposed the measure, and led to the adoption of section twelve of the Act, which is as follows:

Section 12. The provisions of this Act shall be null and void, and the appropriation herein made, including the appropriation heretofore made for the erection of a prison at or near the Town of Folsom, shall be credited back to the General Fund of the treasury, unless the State Prison Directors can make contracts on or before the 30th day of June, 1878, with some responsible party or parties for the hire of not less than three hundred and fifty convicts for terms not less than five years, at a price not to be less than fifty cents per day for each convict; all to be worked on the Branch Prison grounds, under the charge and control of the officers of said prison, and unless the contracting party or parties shall enter into good and sufficient undertakings or bonds in the aggregate sum of $250,000, made to run to, and to be enforced by said Directors, for the use of the State, for the faithful performance of all the conditions of such contracts, one of which shall be that the wages of the convicts shall be paid promptly at the end of each month. The said Directors shall be the sole judges of the sufficiency of any bond, or undertaking, or security offered as hereinbefore provided.

A contract was made by the Board of Directors, in pursuance of the above section, with H. G. Livermore, for the employment of three

hundred and fifty convict laborers for five years, at fifty cents per day, the employment to commence as soon as the prison and prisoners are ready for the purpose. This contract is now held by the estate of the late H. G. Livermore, which is understood to be abundantly able as well as anxious to execute it.

The State Prison Directors, in pursuance of the above Act of 1878, and the requirements of the Act of March 23d, 1876, entitled "An Act to regulate contracts on behalf of the State in relation to erections and buildings," advertised for sealed proposals for furnishing the materials for and doing all the work necessary to the completion of the Branch State Prison, according to the plans and specifications of A. A. Bennett, which the Board had adopted.

Three bids were made—one for the sum of $220,000, one for the sum of $212,000, and one for the sum of $161,500; the latter by Dennis Jordan, to whom the contract was subsequently let on the 25th of July, 1878, for the sum last mentioned.

The contractor was required, by the terms of his contract, to finish the work within fifteen months from the 17th of July, 1878. He proceeded very slowly, and had many difficulties with his laborers and other creditors. During a period of about nine months that he continued the work, in one form or another, his property, consisting of his tools, machinery, and material was attached by his creditors fifteen times, and the laborers struck seventeen times—sometimes for want of pay, and sometimes for higher wages.

His tools, working machinery, and materials were sold at execution sale, by a creditor, on the 26th of February, 1879. He, nevertheless, continued the work with an inadequate force after obtaining the use of the property sold on the 26th.

He was again attached on the 14th of May, and was again sold out on the 30th of the same month. The Directors on the 1st of April took action in the matter under the Act of March 23d, 1876.

We take the following statement from the official report of the Directors:

"Up to the 1st of April, 1879, more than seven months from the commencement of the work, and half of the time in which the whole work was required to be done, the contractor had, according to the estimate of the architect, furnished material and labor only to the value of $19,037 11.

"The Board now fully satisfied, not merely that the work was not prosecuted with that energy and vigor which the contract required, but also that the contractor would not, if left to himself, prosecute it with such energy and vigor, resolved to assume and exercise the powers conferred on them by Section 12 of the Act concering contracts in behalf of the State, in relation to the erection of buildings, etc., approved March 23d, 1876. Accordingly, in pursuance of the provisions of the said Act, the Board made an order on April 1st, 1879, requiring and directing the contractor—Dennis Jordan—to place not less than 150 mechanics and laborers, in such proportions as the exigencies of the work might require, at work on the Branch State Prison, and to keep not less than that number continuously at work thereon.

"This order was not complied with by the contractor, for the reason, as we believe, he was unable to comply with it, for the want of the necessary capital."

On the thirteenth of May, 1879, the Board made another order requiring the contractor to put on a force of men, and to supply necessary material. This order was not complied with.

On the twenty-third of May, the work appeared to be entirely abandoned by Jordan, and the Board commenced to assume the prosecution of the work. At first they borrowed some necessary tools, derricks, etc., and placed a foreman, William Johnson, in charge of the stone work.

On the thirtieth of May, at the Sheriff's sale of the tools, machinery, property, and effects of Dennis Jordan, the Board purchased the tools and working machinery, etc., necessary for their use, and afterwards proceeded vigorously to the completion of the work.

During the nine months of Jordan's work he did very little upon the prison building, and completed only 44 of the 328 cells, and partly finished enough more to make an equivalent for five more, making in all 49 cells.

The Board of Directors pursued the work for about two months, closely adhering to the plans and specifications of A. A. Bennett, the architect, and during the time completed about 50 cells.

At this time it became apparent to the Directors that some modifications were necessary in the plans and specifications, in order to enable them to complete the work within the appropriation.

We take from the official report of the Directors the following statement in regard to the changes that were made:

"After prosecuting the work with a large force of men during the months of June and July, and with the utmost efforts at economy, the Board saw that it would be impossible to complete, or anywhere near complete the prison, with the appropriation made for the purpose. The Board, after full consultation with Mr. Bennett, the architect, Mr. Duncan, the Superintendent of construction, on the part of the State, and Mr. Johnson, the Directors' foreman of stone work, determined to modify very materially the character of some portions of the work required by the specifications of the architect. The changes determined on by the Board did not alter or in any way affect the plan of the building, but went only to the way in which that portion of the work should be done.

"The plan of the building embraced three hundred and twenty-eight cells. Of these only about one hundred were built. The architect's specifications required that the partition walls between the cells should be of dimension stone, pene-hammered. The first change ordered was that these partition walls should be built of rubble work instead of dressed dimension stone.

"The specifications of the architect required that the floors of the cells, both of the lower and upper tiers, should be of dressed granite slabs, extending the whole length of the cell.

"The second change ordered was that, instead of granite slabs for floors in the lower tier of cells, composition stone should be used; and instead of granite slabs for the floors in the upper tier of cells, quarter-inch plate iron, properly stayed and braced, should be used.

"The specifications of the architect required that the floors of the prisoners' kitchen, dining-room, laundry, etc., should be of dressed granite slabs. The third change ordered was that these floors should be made of asphaltum, properly prepared, instead of such granite slabs.

"The specifications of the architect required that the rooms intended

for the use of the officers, should be finished with cornices, center pieces, etc. The fourth change ordered was that such cornices, center pieces, etc., should be dispensed with.

"It was believed by the Board, at the time they ordered these changes in the character of the work, that the prison could be completed with the appropriation already made for the purpose."

The Prison Directors having made the changes above mentioned, were able to complete the whole of the cells and put the roof on the building, though the latter was not accomplished until after the first heavy rains of the season had fallen.

The attention of the committee has been mostly engaged in hearing, and in some measure investigating, the complaints of Dennis Jordan. These complaints are directed against the Prison Directors and Mr. Bennett, the architect. We deem these complaints wholly irrelevant to the subject matter submitted to the committee; nevertheless, they have been so far examined and exposed as to warrant a decided expression that they are wholly groundless.

The salient facts, as shown by the testimony, are few and simple:

Jordan took the contract at a price at which it was impossible for him to perform it. A full consideration of the testimony induces a strong belief that he knew it at the time. What he might have done under a pliant architect must, of course, rest in conjecture. Anxious as Mr. Jordan may be to make it appear otherwise, the testimony clearly shows that he had no excuse whatever for failing in his contract, other than such as is imputable to himself and to his want of credit or means to carry on the work. The Prison Directors for two months followed this original mode of construction before they were convinced of the necessity of adopting a cheaper mode. They claim that by so doing they saved the State at least $70,000, and produced a work substantially as good for the purpose intended as that originally designed; and we think the Directors are justified in the expression of that opinion.

ANALYSIS OF THE MATERIAL PARTS OF THE TESTIMONY, AND CONCLUSIONS THEREFROM.

This investigation seems to have been instigated, or set on foot, by Dennis Jordan, the contractor, for the completion of the Folsom Branch Prison. At least, at the very outset of the investigation, he filed a statement with the committee in which he sets up, first, that if he had not been unjustly dealt with and persecuted by the architect in charge of the work, he would have been able to complete his contract and would have made out of it the net sum of $20,000; and second, that after he had taken Edward Nunan, as a partner in the contract, and they had prosecuted the work for some months and had sub-let some of the work, they figured on the work and made estimates on what the several parts of it would cost, and were satisfied, as the result of such figuring and estimates, that they would be able to complete the contract and make a net profit of $40,000 thereon.

In further support of the position that this investigation was instigated by Dennis Jordan, we beg to quote a statement of the Honorable George W. Tyler, Chairman of the sub-committee charged with

making the investigation, and also some questions which were asked Mr. Jordan on the same occasion, and his answers thereto.

Mr. Tyler said: "I had some conversation with Mr. Jordan as to this matter before I was a candidate for the Legislature, and in speaking about it afterwards I told him that the only way for him to do was, if I was a member of the committee, to come before the committee and make his statement. I preferred to have him make it here instead of making it to me privately."

Question to Jordan: What was your purpose in coming here and reading these statements? Do you want some redress?

Answer—Yes, sir. I wish you gentlemen to sift it out, if there is anything wrong, as legislators, and as the Committee on State Prison.

Question—Do you expect any personal redress in this matter; any compensation in any way for it; do you expect to realize something out of the State by the violation of your contract, as you claim it has been violated?

Answer—Yes, sir. I claim that I have not given up my contract yet.

In his statement, above referred to, Mr. Jordan makes several allegations in support of the assumption that his failure to perform his contract was due to the unjust and oppressive exactions of the architect in requiring him to do better work than the contract and specifications, reasonably interpreted, required, and to improper conduct on his part in other respects. We will hereinafter endeavor to determine how well founded these allegations are, and to what weight they are entitled in this investigation.

We shall attempt to determine from the evidence taken by the committee, first, whether Jordan could have completed the Folsom Branch Prison, as required by the contract and accompanying specifications—the specifications being part of the contract—for the sum specified in the contract, to wit, $161,500; and second, whether there was any improper or unnecessary interference with him in his prosecution of the work by the architect in charge, or by the Board of State Prison Directors, or whether the Directors improperly took charge of the work. As appears by the minutes of the Board of State Prison Directors, there were three bids for the completion of the Folsom Branch Prison, as follows: Hughes & Dudgeon's, $220,000; H. G. Livermore's, $212,000; Dennis Jordan's, $161,500.

It will be observed that Jordan's bid was $58,500, or about 17 per cent. less than Hughes & Dudgeon's, and $50,500, or about 14 per cent. less than Livermore's. This discrepancy between Jordan's bid and the other bids indicates, inevitably, either great ignorance on the part of Jordan, or of the other bidders with regard to what the work bid on would cost, or great recklessness in bidding. It is scarcely probable that contractors, who are always desirous of contracts out of which they can make money, if they had believed that this job could be done for $140,000—and it was necessary that it should be done for about that sum to permit Jordan to make $20,000 on it—would have put their bids in at $220,000 or $212,000. The bids themselves unmistakably show that Jordan's bid was, in the estimation of contractors, below, and materially below what the work could be done for.

As already stated, Jordan sets up that if he had not been improperly interfered with and hindered in the work by the architect, he would have completed his contract and made from $20,000 to $40,000 out of it.

From the evidence before the committee, we shall attempt to determine out of what part of the work, as segregated by the architect, this profit must have been made, if it could have been made at all.

Mr. Bennett's segregation of the work, and the prices fixed for the several parts thereof, are as follows:

328 cells, at $256 61 each		$84,168 00
Masonry other than cells	$22,263 97	
21,231 feet sup. flagging, 35 cents per foot	7,430 85	
Iron work, roofing, etc.	25,000 00	
Carpentering	16,000 00	
Plastering	------	
Plumbing and gas-fitting	2,500 00	
Painting and glazing	2,500 00	
Marble mantels	1,000 00	
Printing	5,000 00	
Vault door	300 00	
		77,494 82
Total		$161,662 82

It will be observed that this schedule of prices allows $84,168 for the stone work of the cells, and $77,494 82 for *all* the other work.

It will be proper now to ascertain, if possible, from the testimony before the committee, what it would have cost Jordan to have done the several lots or classes of work, for which there is allowed, in the architect's schedule of prices, an aggregate of $77,494 82; or, in other words, to ascertain what it would have cost him to perform *all* his contract, except the *stone work of the cells.*

What would it have cost him:

First—To put down the 21,231 feet of flagging?

We think the testimony shows conclusively that it would have cost him at least 75 cents per foot to have laid it down, or $15,923 25 for the lot. We will assume, however, that he could have done it for the price fixed in the architect's schedule—35 cents per foot, or $7,430 85 for the lot.

Second—To have done the iron work, roofing, etc.?

He sub-let the iron work for $28,500; and that, of course, is what it would have cost him.

Third—To have done the wood work and carpentering?

The most of this was sub-let, and the whole of it has been done for $13,741 60, and it would have cost him at least that much.

Fourth—To have done the plumbing and gas-fitting?

This work he sub-let for $2,800.

Fifth—To have done the plastering?

It appears from the minute book of the Board of Directors that the lowest bid received for doing the plastering, on changed specifications, dispensing with cornices, center pieces, etc., was $2,468, and the next lowest, $2,600. From this we conclude that the plastering, according to the specifications in his contract, would have cost him at least $3,100.

Sixth—To have done the painting and glazing?

The painting has not yet been done and no contract has been let, and no bids received, so far as appears for doing it. We will, therefore, assume that it and the glazing can be done for the sum fixed in the architect's schedule of prices—$2,500.

Seventh—The marble mantels have not been purchased, the painting of the outside of the building has not been done, and the vault door has not been procured. We will assume that they would have

cost Jordan no more than the respective sums fixed in the architect's schedule of prices, or $1,800 in the aggregate.

Eighth—To have done all the masonry in the building, except the stone work of the cells?

In the architect's schedule of prices this work aggregates $22,263 97. Very little testimony was taken touching what this class of masonry is worth, or what it would have cost Jordan to have done it. Jordan himself, however, testified that the 90 per cent. which he received on what he did on this class of work paid him for doing it. Without undertaking to determine from the testimony, or in any other way just what Jordan could have done this work for, we will assume, for the purpose of bringing all the work, other than the stone work of the cells, would have cost him, within the architect's schedule of prices for such work, that he could have done it for $17,622 37; or for 79 per cent. of what the architect allowed for it in his schedule of prices. This would allow the contractor 21 per cent. profit on this part of his contract, as determined by the architect's schedule of prices; but this profit would have had to be applied to making up the losses that would have been sustained on other parts of the contract, as determined by the same schedule of prices. Summarizing what it would have cost Jordan to have done the several parts of the work embraced in his contract, except the stone work of the cells, we have:

For all masonry, other than cells	$17,622 37
For flagging	7,430 85
For iron work, roofing, etc.	28,500 00
For carpentering	13,741 60
For plumbing and gas fitting	2,800 00
For plastering	3,100 00
For painting and glazing	2,500 00
For mantels, painting, and vault door	1,800 00
Total	$77,494 82

This is the aggregate of the sums fixed in the architect's schedule of prices for all the several parts of the work, other than the stone work of the cells. In this connection it may be remarked that Mr. Corlett, the committee's expert, who states in his report that Jordan's whole contract might have been performed for $140,626 21, estimates that this portion of the work—that is, all the work except the stone work of the cells, would have cost $77,391 21.

We will assume that this work could have been done for this sum, but we by no means believe that it could.

Thus are all questions touching the cost of all parts of the work, except the stone work of the cells, disposed of. Nothing further need be said to show that it would have cost the contractor to perform the several parts of his contract, other than the stone work of the cells, in the aggregate, all that the architect's schedule of prices allowed for such parts of the work.

From this it necessarily follows that, if the contractor could have completed his contract without actual loss, he must have been able to build the stone work of the cells for the sum fixed by the architect in his schedule of prices, to wit, for $256 61 per cell; and also, that, if he could have cleared $20,000 on his contract, as he alleges he could have done, he must have been able to build cells for $195 64 each; or, if he could have cleared forty thousand dollars on his contract,

as he intimates, he must have been able to build cells for $134 66 each.

The question now arises, what could or what did Jordan build cells for? How much did the building of cells cost him per cell?

A satisfactory answer to this question will dispose of the questions: first, as to whether he could have performed his contract for the sum named therein; and, second, as to whether he could have made $20,000, or any other sum out of the contract.

The building of a cell consists of these parts: The quarrying of the stone, the cutting of the stone, and the setting.

Testimony has been taken as to what each of these cost Jordan.

John L. Grant, who was Jordan's foreman of quarrying, testified that the stone, taking it all together, might be got out for 35 cents per cubic foot, and that no part of the stone cost more than 40 cents for quarrying. And yet, on cross-examination, he testified that it would cost 60 cents per cubic foot to quarry the stone, which would become the ceilings of the lower and floors of the upper tier of cells. It is rather difficult to determine precisely what he did testify as to the cost per cubic foot of quarrying dimension stone for cells; but looking at his testimony alone, we are justified in the conclusion that it cost Jordan 40 cents per cubic foot at least to quarry dimension cell stone.

There are in each cell, according to the architect's segregation, 305½ cubic feet of dimension stone, consequently the quarrying of the stone for a cell must have cost Jordan $122 20. This conclusion is, of course, drawn wholly from Grant's testimony concerning the cost of quarrying dimension stone.

What did the cutting cost him?

It appears from the testimony that Jordan, taking advantage of the necessities of the stone-cutters, there being but little demand for stone-cutting, undertook to get stone cut at very low rates. John B. Kelly, who worked for Jordan at stone-cutting in the months of October, November, and December, 1878, testified that in October the stone-cutters were receiving fifteen cents a superficial foot for faces, and ten cents for beds; that a Stone-cutters' Association was then formed, and that the stone-cutters struck for higher prices. They demanded twenty cents per superficial foot for faces, and fifteen cents for beds, or $3 50 per day. After the lapse of some weeks, a compromise was agreed on, by which the stone-cutters were to receive fifteen cents all round per superficial foot; twenty cents per superficial foot for faces of floors, and ten cents per foot for joints of floors, or $3 50 per day for some good men, $3 25 for others, and $3 for still others. Mr. Kelly explained that there was that difference in the value of men's labor. This compromise was made in December, 1878.

Jordan testified that the men in his employ struck seventeen times while he was carrying on work on his contract; and Grant, when asked the reason of the strikes, said: "The prices paid were not considered high enough by the Stone-cutters' Union." He further said, "that some of the men were working for a little more than board, and that some of them, during the rainy season, did not earn a dollar and a half a day."

Daniel McHenry, a foreman of stone-cutters for Jordan, commenced work at the prison in December, 1878. McHenry testified that when he took charge of the stone-cutting, the stone-cutters were

receiving fifteen cents per superficial foot all round, and that, at that price, it cost $110 per cell for cutting.

He further testifies, that, at the suggestion of the architect, he caused the cutting to be done better and better from day to day, or from time to time, till finally it cost 20 or 25 cents more per foot than it had done at first.

It appears from the testimony that the architect condemned some of the cutting as not coming up to the requirements of the specifications. Moreover, it appears from McHenry's testimony that it took more than double the labor originally bestowed on it to bring it to the proper standard, unless the architect demanded better work than a reasonable interpretation of the specifications would have required. From 15 cents per superficial foot all round, he got finally to putting on 20 and 25 cents additional work on each foot. We will inquire hereafter whether, with all this additional labor, the cutting was better than the specifications called for. We accept, for the present, McHenry's statement that he did, on the start, cut cells for $110 each.

Now, what did it cost Jordan to have the stone set after they were quarried and cut?

McHenry, who does not profess to be a mason, thought Jordan had cells set for $32 50 each. Grant, who testified that he had had much experience in setting as well as in quarrying and cutting stone, said it never cost less than 12½ or 15 cents per foot for setting, or about $45 per cell.

Now, from the testimony of Grant and McHenry, one the foreman of his quarrymen and the other the foreman of his stone-cutters, and both manifestly desirous to support, as far as possible, Jordan's claim as to what he could have done the work for—as to what it cost Jordan to *quarry* and *cut* and *set* the stone in a cell, we have the following:

For quarrying	$122 50
For cutting	110 00
For setting (as per McHenry)	32 50
Cost per cell	$265 00

Or, taking Grant's estimate of the cost of setting a cell, to wit, $45—and of the two his estimate ought to be considered the more trustworthy, as he claimed to have had experience in setting stone—the cost per cell was $277 50.

It will be observed that these conclusions as to what it cost Jordan to build cells are deduced wholly from the testimony of two of his own foremen, which testimony, it was evidently supposed, would support the pretense of Jordan that if he had not been improperly treated by the architect he could have completed his contract and made $20,000 profit out of it.

It will be seen that, if it cost him to set a cell only what McHenry thinks it did, he would still have lost $8 39 on each cell—or $2,751 92 on the job. If, however, it cost what Grant said it must have cost, he would have lost $20 89 on each cell—or $6,851 92 on the job.

The compromise between Jordan and the stone-cutters to which John B. Kelly, one of Jordan's witnesses, testified, was on this basis, to wit: The stone-cutters were to receive for walls 15 cents all round per superficial foot, 20 cents per superficial foot for surfaces of floors,

and 10 cents for joints of floors; or $3 50 per man for some good men, $3 25 for others, and $3 00 for still others. This compromise was made in December, 1878. McHenry became foreman of stone-cutters in December of the same year, and testifies that when he took charge the stone-cutters were receiving 15 cents a superficial foot all round.

According to the prices, established by the compromise to which Kelly testified, it would have cost to cut the stone in a cell as follows:

Walls and door-jambs, 686 feet, at 15 cents per foot	$102 90
Floors—faces, 145, at 20 cents per foot	29 00
Floors—joints, 40, at 10 cents per foot	4 00
Total cost cutting cell	$135 90
Or, at the prices testified to by McHenry, it would have cost as follows:	
Total superficial feet in cell 871, at 15 cents	$130 65

Now, if we take the cost of cutting stone for a cell at the prices fixed by the compromise of December, 1878—and we do not think it probable that the stone-cutters, in the striking mood, in which they then seemed to be, ever submitted to any reduction of the rates then agreed upon—and take, also, Grant's estimate of which it cost Jordan to set cells, we have, as the cost of a cell, the following:

For quarrying	$122 50
For cutting	135 90
For setting	45 00
	$303 40

This additional cost for cutting, over which McHenry placed it at, is reached, it will be observed, by deducting the cost from the prices fixed by a compromise, after the stone-cutters had struck, very soon after Jordan commenced work. Very little stone had been cut before this strike occurred, and it is safe to conclude that no stone was ever cut afterwards at lower rates than fixed by the compromise.

Now, then, according to the testimony of his own witnesses, it would have been impossible for Jordan to have built cells, after early in December, 1878, for less than $303 40 each. And building them at that cost he must have lost $46 79 on each cell, and $15,347 12 on his job.

In the above estimate of the cost of cutting stone, no account has been taken of the cost of tools, the wear of tools, nor the cost of sharpening them. This would, no doubt, amount to several dollars additional for each cell.

Grant testified, it is true, that he believed "Jordan could have got away with his contract, if it had not been for the prejudice of the architect against him;" and that "he would have got away with it, with any other architect than A. A. Bennett."

Were it not for the animus which he exhibited throughout his testimony toward Mr. Bennett, we might have supposed the above expressions intended as compliments to that gentleman, but the bitterness toward him which he permitted to crop out on several occasions during the delivery of his testimony, precludes the idea that he used them for any such purpose.

To what credit his testimony above quoted, is properly entitled may be deduced from his testimony on cross-examination on the same subject.

He testified that, when bids were solicited for completing the Fol-

som Branch Prison, he made an estimate on the work, as a basis of a bid for the contract. From the specifications, as they were at that time, he understood that no peine-hammered work would be required on the cells, and his estimate, on what it would be worth to build the cells, was based on that assumption—on the assumption that the cells were to be built of coarse dimension stone, but not peine-hammered. On this assumption his estimate for the whole building, as the basis of a bid for the contract, was $198,000; and his estimate for the cells was $95,120—or $290 for each cell.

The specifications, however, in Jordan's contract, he perceived, were not the same as those on which he made his estimate. They now required the stone of the cells to be peine-hammered. In consequence of this interlineation in the specifications, as he called it, he would make an addition to his estimate of $24,500, to cover the cost of the additional labor of doing the peine-hammering required.

This addition would make his estimate for the whole building $222,500; for the cells, $119,620; and for each cell $364 70.

As already shown, Jordan, to have kept even on his contract, must have built the cells for $256 61 each, or for $84,168 for the whole. Now Grant's estimate for cells of dimension stone—not peine-hammered—was $290 each; or $33 29 more than Jordan must have built peine-hammered cells for; and his estimate for the whole of the cells, of such dimension stone, was $95,120, or $10,952 more than Jordan must have built the cells for of peine-hammered stone.

And again, Grant's estimate for peine-hammered cells, as required by the Jordan contract, was $364 90 each, or $108 29 more than Jordan must have built such cells for, to have kept even; and his estimate for the whole lot of cells was $119,620, or $35,452 more than Jordan must have built them for, "to have got away with his contract."

We will leave it for Grant to reconcile with this testimony, which was given after time for full deliberation, his previous statement, that, in his opinion, Jordan could have performed his contract for the stipulated compensation, if it had not been for the prejudice of the architect against him, or if there had been any other architect than A. A. Bennett in charge of the work.

We have shown what it must have cost Jordan to build cells according to the testimony of three of his employés on the work, whom he caused to be placed on the stand, to show what it had actually cost him to have the work done. We will now show from Jordan's own testimony what it cost him to build cells. It appears from Mr. Jordan's testimony:

First—That when he took possession of the Branch Prison, he found there material, which became his by virtue of his contract, as follows:

Cut stone amounting to	$4,000
One hundred and seventy-five barrels of cement	525
Lime and sand	150
Total	$4,675

Second—That he and his partner, Edward Nunan, put into the building $18,000 in gold coin.

Third—That he had machinery, tools, etc., of the value of $2,500 at the time he took the contract, which he took to the prison and used in prosecuting the contract; that these tools, etc., were levied on and

sold under execution, and the proceeds applied to the payment of debts he had created in prosecuting his contract.

Fourth—That all the money he had received from the State on his contract, except a sum not exceeding $700, he had expended for labor and material to carry on the contract.

Fifth—That for all masonry on the front building, the cell building, the new approach building, and the water closet—in a word, for all masonry which he did, except that on the cells, he received from the State as much as it cost him; or would have received as much if there had been no mistake in the measurement.

The remeasurement, made on the 12th of June, 1879, to which reference will hereinafter be made, showed the measurement of this part of the work to have been short only $450 90, while the minutes of the Board of Directors show that on the 13th of May, 1879, the Board allowed Jordan $1,137 60 additional on work which had already been allowed for up to the full schedule price, and reduced by an equal amount the schedule price of work which he would not have to do till towards the close of the job. The Board did this, as appears from the testimony, that he might have money enough to pay his men and proceed with the work. It thus appears that he actually received more for this work than he would have been entitled to merely on a full measurement.

Sixth—That he paid to the sub-contractor of the iron work only such sums as he received from the State for iron work.

Seventh—That he thought, though he was not certain, that he had received from the State for the small amount of carpenter work he had done as much as it had cost him.

Eighth—That he had done no plumbing, plastering, nor glazing.

It appears from the architect's progress estimates that Jordan built 49 cells, or the equivalent of 49 cells, and that he received for such work $11,493.

From this testimony, there must have gone into the construction of the cells:

Cut stone on hand	$4,000 00
Gold coin	18,000 00
Machinery, etc.	2,500 00
Amount received for cell work	11,493 00
	$35,993 00
Less	700 00
	$35,293 00

Mr. Jordan has not testified to the amount of cut stone he came into possession of at the prison by virtue of his contract, but only to its value. We must deduce its amount from its value; it was not, of course, worth more than it would have cost him to have taken an equal amount from the quarry and cut it. He says that, without interference from the architect, he would have made $20,000, net, on his contract. We have already seen that to have made that sum he must have built the cells for $195 63 each; and Corlett, the committee's expert, estimates that he could have done it. Now, if we allow that it would have cost him, when working on this basis, $30 to have set a cell, the quarrying and cutting of the stone would have cost $165 63. And, consequently, in a quantity of stone worth $4,000 there would have been enough to build 24 cells.

On the basis on which Mr. Jordan must have estimated the value of the cut stone he found at the prison, the $4,000 worth which then was there must have been the equivalent of at least twenty completed cells. He had, therefore, in this cut stone, the equivalent of twenty cells already built when he commenced work on his contract.

Now, we will assume that he expended $4,000 in opening the quarry and making other improvements, the cost of which should not be charged to the work alone which he did before abandoning his contract, but should be distributed in proper proportions to all parts of the job. Deducting now the $4,000—the value of the cut stone on the ground when Jordan took possession, and which stands as the equivalent of twenty cells—and the $4,000 assumed to have been used in opening the quarry, etc., from $35,293, and we have $27,293 as the sum which it cost Jordan to build twenty-nine cells. This gives as the cost per cell, $941 17. This is the inevitable conclusion from Jordan's testimony, if we take as part of that testimony his statement, made under oath, that he could have cleared $20,000 on his contract if he had received proper treatment from the architect. If, however, we discard that statement, as not to be considered a part of his testimony, we have the following:

Total sum expended on cells	$35,293 00
Deduct for amount expended in opening quarry, etc.	4,000 00
Net amount expended on cells	$31,293 00

This is the amount expended by Jordan in building forty-nine cells, as shown by his own testimony. It is thus seen that it cost him $638 63 per cell. On this basis, it would have cost him to complete the building:

Three hundred and twenty-eight cells, at $638 63 each	$209,471 64
All other work	77,494 82
Total	$286,966 46

This conclusion is the logical outcome of Jordan's own testimony. He says if he had been properly treated by the architect, he could have completed his contract for $140,000; and Mr. Corlett, the committee's expert, echoes Mr. Jordan, and says he could have done it. The inexorable logic of Jordan's own testimony, however, declares that, at the rate he was proceeding, it would have cost him considerably more than double that sum to have completed it.

We deem comment unnecessary.

We come now to inquire whether there was any improper or unnecessary interference with Mr. Jordan in the prosecution of his contract by the architect, or by the Board of Prison Directors, and whether the Directors improperly took charge of and prosecuted the work.

Mr. Jordan charges in his statement that, while his contract required that his work should be measured at the end of each month, and he should be paid 90 per cent. of the estimated value of the work done during the month, the architect neglected to measure his work, after he commenced, till the middle of November, 1878, a period of three months or more; and that he neglected to measure the work as required by the contract, for the purpose of keeping him out of the money due him, with the view of embarrassing him, and driving him ultimately from the contract.

In opposition to this charge is the testimony of Mr. Bennett, the architect, and of Governor Irwin, one of the Prison Directors, who state that the measurement and estimate of the work were deferred till the time named, at the request of Mr. Jordan, himself, and his partner, Mr. Nunan.

By the terms of the contract, the contractor was not to receive pay for any work or material till the same should enter into and become part of the building. And, no doubt, he was compelled to do considerable work, in opening the quarry and making other preparations at the start, for which he was not entitled to any pay. And it seems that when the first measurement of work was made, about the middle of November, there was still only a small amount of work—a little over $4,000 worth—in the building.

Jordan does not claim that he made any complaint to the Directors that they or the architect were violating the contract and injuring him by not measuring his work. And there does not appear to have been any motive—at least on the part of the Directors—for the withholding from him of money due him. Their course subsequently, as will hereinafter appear, shows that they were ready to do everything in their power to aid him in the prosecution of his contract.

Jordan, on the other hand, had this motive for not desiring an estimate till he should have sufficient work in the building to bring a considerable sum; he knew that if he got his money from the State, and did not pay off his employés, there would, in all probability, be a strike among them. Hence his request to the architect and Directors, that no estimate of his work be made till the time at which it was made.

Mr. Jordan charges also that Mr. Bennett instigated his men to strike, and his creditors to attach his property. We are unable to discover that there has been a particle of proof adduced to support these charges.

Mr. Jordan charges also that Mr. Bennett embarrassed him, and hindered the progress of the work, and finally drove him from it, by requiring the work to be done better than the specifications called for, and by condemning, and requiring him to take up work already done; first, as to requiring him to do better work than the specifications called for. The specifications called for *first class* peine-hammered work.

There may have been some testimony tending to show that Bennett was disposed to exact better work than was strictly necessary for a prison, and that some work which he condemned was good enough for a prison; but there has been no testimony of any expert produced before the committee, or of any one skilled in stone-cutting, to the effect that the stone is cut better or finer than the requirements of the specifications.

Grant, though very bitter toward Bennett, would not say that he exacted better work than the specifications called for. Corlett, who was sent as an expert to examine the building, does not report that the work shows the architect to have been too rigorous in his exactions as to the quality of the work. And John Lee, a mechanic of great experience and skill in all classes of stone masonry, testified, after having examined the work and specifications, that there was none of the work in the cells that came up, or anywhere near up, to the demands of the specifications. Said he: "The specifications call

for *first* class peine-hammered work; and the best there is hardly above *third* class."

The specifications, perhaps, called for an unnecessary fine class of work—and it is our opinion that they did—but we do not think from the testimony that the architect demanded a better class of work than that required by the specifications, or even as good a class.

To what extent, or how much work was condemned and required to be taken up, after it had been laid in the walls, does not very clearly appear from the testimony. It is in evidence that some was condemned which was never removed, and it does not appear that any considerable amount ever was removed after once being laid up. Furthermore, we think no work was ever ordered removed which did not plainly, and even conspicuously, fall below the manifest requirements of the specifications. The testimony on this point will, we think, warrant these conclusions:

First—That the contractor incurred but very little expense in tearing down and rebuilding work once built.

Second—That in the instances in which he was required to and actually did tear down and rebuild work, the work required to be torn down was so manifestly and so greatly below the requirements of the specifications that no architect, with the least regard for his reputation, could have permitted it to stand.

Mr. Jordan charges, also, that the architect did not measure correctly his work from month to month; and that, in consequence of such errors in the measurements, he did not receive from the State, at his monthly payments, as much as he should have received; and that through this failure of the State to pay him, from month to month, what was justly due him, he was unable to pay his laborers and meet his other obligations.

It appears from the testimony that Jordan refused to accept the estimate of the architect on the work done in May, 1879, and called for a remeasurement of the work; that his demand for a remeasurement was promptly acceeded to by the Board of Directors; and that a remeasurement was made on the 12th of June; such remeasurement having been made by William Johnston, on the part of the State, and by Mr. Jordan himself. At this time all the work Mr. Jordan had done on the contract was measured, and such measurement gave him some $2,700 more than the aggregate of the several progress estimates of the work made by the architect.

Of this $2,700, over $1,500 was for cell work, $700 for iron work, and the remainder for rubble masonry.

There is nothing in the testimony from which we can determine with certainty, at what time the error in the architect's measurements, on which his progress estimates were based, occurred. It is true, Jordan sets up, that this error in the measurement occurred, at least the greater part of it, in November, 1878, when his work was measured for his first progress estimate. This, however, is improbable, for two reasons:

First—The mismeasurement in cell work is equivalent to six whole cells. It is impossible that the architect would have failed to measure, and would have omitted from his estimate, that amount of cell work when the building of cells had but just commenced; and,

Second—If the architect had committed such a flagrant error in his estimate, it is not probable that the contractor would have permitted

it to pass without calling the attention of the Directors to it, and demanding a remeasurement.

It appears from the testimony that the contractor never demanded a remeasurement of the work, or of any portion of it, till after the progress estimate had been made on the work which he had done in May. It appears, also, that the progress estimate of his work, done in April, did not furnish him with money enough to pay his laborers for that month. And in consequence of this deficit he applied to the Directors for assistance. He did not, however, claim that there was money due him in consequence of short measurements, and demand a remeasurement that he might get his just dues. On the contrary he claimed that that portion of the foundation of the new approach building, in excess of 2,000 feet, ought to be paid for as extra work, though the specifications required him to excavate to and start the foundation on solid granite. The Board finally allowed him 15 cents per foot extra on 7,000 feet and over of this foundation, making $1,122. But this did not still provide him with money enough to pay off his men. The Board then, that he might have money enough to pay his men and be able to proceed with the work, allowed him 12 cents additional per cubic foot on the whole of this foundation—more than 9,000 cubic feet—though he had been allowed originally the schedule price, 15 cents per cubic foot, and subsequently 15 cents more, on over 7,000 feet of it, which was not to be counted in his contract, but as extra. The twelve cents additional, now allowed him on each cubic foot of this foundation—amounting to $1,137 60—was in the nature of a loan, to assist him through the then existing emergency; it being mutually agreed between him and the Directors that they should reserve a like amount from sums which would become due him, according to the architect's schedule of prices for certain specified work, to be done on toward the end of the job.

Had the contractor known of any error in the measurements prior to this time, or had he even suspected any, is it not probable that he would have demanded a remeasurement? And is it not probable, also, that the Directors, who seem to have been sincerely desirous to assist him as far as they could, would have preferred to have done so by paying him what the State owed him, if they had known or had had reason to suppose that the State did owe him, rather than to have caused a change in the architect's schedule of prices, that they might let him have money which he had not yet earned?

The evidence shows, first, that there never was a demand for a remeasurement of the work, or of any part of the work, till after the progress estimate of the work done in May was made; and, second, it does not show that there was any error in the measurement of any part of the work prior to the measurement of the work done in May. The probabilities are all against the existence of errors prior to such measurement.

Mr. Jordan charges, in a vague way, that Mr. Bennett had entered into a conspiracy with the Natoma Ditch Company, or with the late H. G. Livermore, formerly the President of that company, to embarrass him in carrying on his contract, and to drive him from the work.

In support of this charge he referred in his statement, in evidence before the committee, to conversations which Mr. Bennett had had with Edward Casey. To support the charge Mr. Jordan had Mr. Casey brought before the committee to testify.

The substance of his testimony was that Bennett, in conversation

with him, had expressed great anxiety to have the prison completed during the then existing administration; that he did not believe that Jordan would be able to go on with and complete the job; and that he asked him to write to Duncan, with whom he was on intimate relations, and urge him to spur Jordan to hurry up the work. We are unable to discover from any testimony before the committee that Mr. Bennett, at any time or in any manner, directly or indirectly, interfered with Mr. Jordan in the prosecution of his contract, except in so far as it became necessary to do so to secure a reasonable compliance with the specifications in accordance with which the work was to be done. On the contrary, the testimony of the experts, so far as it goes, is to the effect that instead of being too rigorous in exacting compliance with the extreme letter of the specifications, he was too lenient. Corlett, the committee's expert, is silent on the question as to whether or not the architect had exacted of the contractor better work than the specifications called for. Lee, however, who is a thoroughly competent mechanic, testified that, while the specifications called for *first* class peine-hammered work, the work actually done was hardly above *third* class.

It is thus shown that Bennett, so far from putting obstacles in the way of Jordan, was disposed, in order that he might get along with the job, to accept work, and did accept work below, and very much below, what the specifications required; and which, if he had wished to hinder the prosecution of the work, he might, and no doubt would, have condemned.

Jordan charges, also, that the Directors improperly took charge of the work, and ejected him from it.

The Board had let the contract for the construction of the Branch Prison, and were supervising the work under the provisions of an Act entitled "An Act to regulate contracts on behalf of the State, in relation to erections and buildings," approved March 23d, 1876. The twelfth section of said Act provides, that whenever, in the opinion of the Board having charge of the construction of any building, or other structure, the labor on such building or structure is not prosecuted with such vigor and rapidity as the contract calls for, such Board may order the contractor to put at work a specified number of workmen, or to procure specific material; and that if he does not comply with the order within twenty days from its date, the Board, itself, may employ and set to work the specified number of men, or furnish the required material.

Jordan's contract was awarded to him on the 17th of July, 1878, and by its terms, it was to be completed within fifteen months from that date. Up to the 1st of April, 1879—more than nine months after the contract was awarded—there had been done on it, according to the architect's estimates, only $19,037 11 worth of work. Thus, while considerable more than half the time in which the work was to be done had elapsed, considerably less than one-eighth of the work had been performed. The Board deemed that this state of facts would not merely justify their assumption and exercise of the powers conferred in the provisions of law above referred to, but that it made it their duty to assume and exercise such power. Accordingly, on the 1st day of April, 1879, the Board made an order directing the contractor to place on the work, and keep continuously employed thereon, not less than 150 men. Early in May all, or nearly all, work on the

job stopped, the men having struck. On the 14th of May all the machinery, tools, and other property used by Jordan on the work were levied on by the Sheriff; and from and after that date up to the 23d of May, at which time the Board in pursuance of their order of April first placed men on the job, Jordan did not have a solitary man at work.

On the 13th of May the Board made the second order, directing the contractor to place on the work an additional number of men and to procure certain specified material, which would be required to complete his contract. As already stated, on the 14th, all his machinery, tools, and other property, by means of which he performed work on his contract, were levied on by the Sheriff, and on the 30th of May sold. This machinery, etc., was purchased by the Directors; and it is in evidence that Mr. Jordan applied to them to be permitted to use it in prosecuting the work on his contract, but was refused. It does not appear, however, that he at any time after the sale of his machinery, etc., by the Sheriff on the 30th of May, procured other machinery, or hired men, or attempted, or offered to go to work on the job.

After the lapse of twenty days from the date of this second order, directing the contractor to place on the work additional men, material, etc., the Directors, in pursuance of such order, caused additional men to be employed and additional material to be purchased from time to time, as the exigencies of the work required.

From the above facts, taken from the testimony before the committee, we are of the opinion:

First—That the tardiness of the contractor in prosecuting the work had made it the duty of the Board to take action under section twelve, of the Act of March 23d, 1876.

Second—That on the 23d of May, 1879, when the Board placed men on the work, in pursuance of their order of April 1st, the contractor was not complying with such order—he having had no men at work for ten days—and it was lawful and proper for the Board to do as they did.

Third—That it does not appear that the contractor would ever have been able to do any more work on the contract after the levy on his machinery by the Sheriff on the 14th of May, 1879, and its sale on the 30th of May, 1879.

He was driven from the contract, not by the Directors, but by his creditors, who took from him, under execution, the only means by which he could prosecute it.

It appears from the testimony that when the Board found the necessity forced on them of placing men on the work, they made extensive inquiries among architects and builders, with a view of procuring such information touching mechanics skilled in stone work as would enable them to select a competent and suitable person to take charge of the work, or of such portion of it as they should find it necessary to perform. As the result of their inquiries they selected William Johnston, who took charge of the stone work at the prison on tbe 23d of May, 1879. All the stone work of every kind, including the quarrying, cutting, and setting, done after that date was done under his immediate direction and supervision.

The work was continued, according to the specifications in the Jordan contract, during the months of June and July, when the Directors became satisfied, it was costing so much to build the cells of peine-

hammered stone, that they would not be able to complete, or anywhere near complete, the prison with the money appropriated for the purpose. They accordingly began to consider whether a change could not be made in the manner of constructing the cells—that is, in the character of the work, by which cells, just as good for all practical purposes, might be built at a very greatly reduced cost. A meeting of the Directors was called, at which Mr. Bennett, the architect, and Mr. Johnston, the foreman of the stone work, were present. As the result of this conference, the Board determined to stop the construction of cells of dimension peine-hammered stone, and to build, instead, cells with fronts very similar to those of the dimension stone cells, but with rubble stone partitions. It was the opinion of Mr. Bennett and of Mr. Johnston that it would be just as difficult for a person to escape from a cell built in this way as it would to escape from one of the dimension stone cells. To escape from either, he must make his way through the front of the cell, and it would be as easy for him to get through the stone front of the one as of the other; besides, it was their opinion that the iron door, which is precisely the same in both classes of cells, would be the weakest part of the cell, and the part through which a prisoner, bent on escaping, would be most likely to attempt an exit. The Board, concurring in these views, determined to make the necessary changes in the specifications, and also to make certain other changes, as appears by their minutes, of less consequence.

The Board, in making these changes, acted in pursuance of sections four and five of the Act of March 23d, 1876, entitled "An Act to regulate contracts, etc."

There has been no testimony introduced showing, or tending to show, that the "rubble cells," built in pursuance of the changes made by the Directors in the specifications, are not practically as good for the purpose for which they are to be used as those built of peine-hammered dimension stone; none that it will not be just as difficult for a prisoner to escape from one of them as from one of the others.

Corlett's report, while it reflects on the character of the rubble work masonry, does not utter a word against the cells, as not being strong enough to prevent the escape of prisoners. And John Lee, while strongly reprobating the act of the Directors in substituting rubble for dimension stone in the cells, and characterizing it as an outrage, expressed the unqualified opinion that it would be just as difficult for a prisoner to get through the front of the "rubble cells" as through the front of one of the others; and he thought that if a prisoner should resolve to escape he would attempt to cut through the iron door, and not through the stone front of his cell.

It not being seriously contested but what the "rubble cells," so-called, will offer just as effectual an obstruction to the escape of prisoners as the peine-hammered dimension stone cells, it remains to inquire whether the difference in the cost of the two classes of cells was sufficient to justify the Directors in making the change from the latter to the former. It will be proper now to ascertain, if possible, from the testimony before the committee: first, what it cost the Directors to build peine-hammered dimension stone cells; second, what it cost them to build the rubble stone cells.

Very considerable testimony was taken by the committee touching the cost of quarrying dimension stone, such as those required for the cells, under the Jordan contract. Corlett, the committee's expert,

placed the quarrying of such stone at ten cents per cubic foot, but this estimate of the cost is manifestly so low as to be absurd, and clearly is entitled to no consideration whatever. We have already seen that the testimony of Grant, who was a foreman quarryman for Jordan, is somewhat vague on the subject of the cost of quarrying; but that he estimates the cost of quarrying such stone as were required for the cells as high, at least, as forty cents per cubic foot. Mr. Griffith, the proprietor of the granite quarry at Penryn, the most extensive quarry in the State, and who has followed quarrying and cutting granite for the San Francisco and other markets of the State for the last fifteen years, and whose appliances for quarrying are of the most complete and perfect character, testified that it cost him, to quarry dimension stone, fifty cents per cubic foot. I. N. Taylor, the proprietor of a granite quarry at Rocklin, and who has followed the quarrying and cutting of granite for the last ten years or more, testified that it cost him, on the average, about seventy-five cents per cubic foot, to quarry dimension stone. William Cook, an experienced quarryman, who is the owner of a granite quarry on the opposite side of the American River from the site of the Branch Prison, testified that some years ago he had a contract for several thousand feet of dimension stone, to be taken from the quarry of the Natoma Ditch Company, the stone being similar to that in the State quarry, and that it cost him seventy-four cents per cubic foot to quarry it.

Peter McCubbin, who was foreman in the State's quarry after the Directors took charge of the work, testified that a quarryman did not quarry, on the average, over four feet of dimension stone a day; and that the other expenses of quarrying, added to the wages of the quarryman, would bring the cost of quarrying to 75 cents per cubic foot.

From the testimony before the committee, we have no doubt that it cost the State all of 75 cents per cubic foot to quarry dimension stone, and we think even more, unless a part of the cost of quarrying was charged to the account of the rubble which was taken out with the dimension stone. Thus, the cost of quarrying the dimension stone for a cell, there being 305½ cubic feet in a cell, would be $229 12.

Mr. Johnston, the Directors' foreman of stone work, devised a system of cards by which a record was kept of the number of feet in each stone, the time when the stone-cutter commenced to cut it and when he finished, and the number of hours he was engaged on it. By means of these cards, which have been preserved, we can tell what it cost to cut each stone.

From several of these cards, selected as an average of the whole and filed with the committee, it appears that it cost $212 75 to cut the stone for a cell. This was for cutting alone, no account being taken of the cost of tools, or of sharpening them. This, no doubt, would add $20 to the cost of cutting each cell. Thus would the cost to the State of cutting the stone for a cell be raised to $232 75.

What did it cost the State to have the stone in a cell set?

As we have already seen, McHenry thought it did not cost Jordan over $32 50, while Grant was confident it could not have cost him less than $45. Mr. Johnston estimates that it cost the State 12 cents per foot for setting the stone of a cell, and $2 for furnishing and putting in the rim clamps, thus making the whole cost of setting a cell $38 66.

Thus we have, as the cost to the State of a peine-hammered dimension stone cell:

For quarrying	$229 12
For cutting	232 75
For setting	38 66
Total	$500 53

Now, what was the cost to the State of the rubble cells?

Mr. Johnston, foreman of the stonework, estimated the cells built, and the dimension stone quarried and cut, but not yet laid up when the change in the manner of building the cells was determined on, as the equivalent of one hundred cells. These dimension stone were used for the fronts and roofs of the rubble cells. On the basis of this estimate, there was built two hundred and twenty-four rubble stone cells, or the equivalent of that number.

These cells cost, according to a statement taken from the accounts kept by the Directors, and in evidence before the committee, the sum of $42,463 57.

This sum was expended as follows:

For labor	$31,360 34
For material	5,823 23
For iron floors	5,280 00
	$42,463 57

Thus the cost per cell was $189 56, as against $500 53 per cell of dimension stone.

Thus we have:

Two hundred and twenty-four cells, at $500 each	$112,000
Two hundred and twenty-four cells, at $190 each	42,560
	$69,440

Thus it appears that the rubble cells cost nearly $70,000 less than the same number of peine-hammered dimension stone cells would have cost.

Some testimony has been introduced bearing on the question, as to whether the men employed worked as well after the Directors took charge of the work as they had done before.

Grant, who manifestly entertained no friendly feeling for the foreman, Mr. Johnston, when asked if the latter seemed to take as much interest in pushing the work forward as he could have done if he had had the contract himself? replied, "that he seemed to take great interest, so far as keeping the men constantly at work was concerned;" and to the question, "Is it your opinion that the men who worked there after the State took charge were required to work as well and as steadily as Mr. Jordan worked his men?" He answered: "I think they were required to do that. In my department, and wherever I worked, the stone-cutters and quarrymen worked faithfully."

Grant subsequently testified, in explanation or modification of the above, that owing to the debilitated condition of the stone-cutters, through sickness and the great heat, they were not able to cut as much stone by 25 per cent. as they could when Jordan was carrying on the work.

McHenry, when asked if the men worked as well for the State as they had done for Jordan, replied that they did not; that they were made to do about so much work, and that they would not do any

more; that you could not get any more out of them. And to the question: "Were they not required to work faithfully?" replied: "Oh, they kept working away." And to the question: "Did you get instructions from Mr. Johnston to discharge incompetent men at any time, and at all times?" he answered: "I did, sir. He said if there was any man that didn't fill the bill, to discharge him if he couldn't do the work."

James Haworth, who had charge of the accounts during the period that Mr. Johnston was foreman of the stone work, and who has had large experience in working men, testified that, in his opinion, Mr. Johnston organized judiciously, and handled to advantage the large number of men under his control, and that he had never seen men work harder on any public or private work, by the day, than they worked on the Folsom Branch Prison.

And James W. Duncan, who was Superintendent of construction on the part of the State, testified that Johnston made all possible efforts to hurry the work along; that he could not have worked the men more advantageously than he did; and that there was no waste of time nor material.

We think the testimony shows that Mr. Johnston, the Directors' foreman of stone work, was a competent mechanic; that he exhibited good capacity and judgment in organizing and working the men under his charge; and that, in prosecuting the work, he showed great energy, and true fidelity to the interests of the State.

We think the testimony shows also that the mechanics and laborers employed on the work, though they may not have done as much work as they would have done for a private individual, worked better than men usually do on public work.

CORLETT'S REPORT.

We regard this report as wholly worthless and unreliable for any purpose connected with the investigation. It does not profess to be the report of an architect upon the character and cost of the prison building based upon his own opinion, founded upon his own investigations. According to the report itself, and the oral testimony of its author in explanation of it, his estimates are based upon his understanding of the testimony, or rather of so much of the testimony taken by the committee as had been brought to his attention. He had, as he admits, heard but a small part of that testimony, and certain selected portions of it had been read to him by somebody from the Reporter's notes. He says: "In the preparation of the foregoing estimates" (the same being all his estimates), "I have based my calculations on the different statements deduced from the testimony of the several witnesses." Again he assumes to reject the testimony of some of the most intelligent and expert witnesses upon one of the most important questions, and upon which the testimony taken was more free from vagueness and ambiguity, and was more clear and decisive, and less conflicting than any other class of testimony taken by the committee. He says: "That portion of the testimony relating to the quarrying of the stone being given in such a vague and ambiguous manner as to preclude any value set on the same as a criterion for my calculations."

We suppose it is the province of the committee to accept or reject testimony; to weigh the same, and reconcile conflicting statements.

The assumption of this authority by one who is a mere witness himself is certainly a novel proceeding, and does not at all commend itself to our approbation. It is not to be presumed that this authority was delegated to him, although it is but just to observe that, by way of explanation or apology for this remarkable report, the author in his oral testimony says that he made it in pursuance of his instructions, and that if he had been engaged to make an examination based upon his own investigations and experience as an architect, he would not have reported as he did.

In the matter of estimating the cost of *quarrying* the dimension stone used in the construction of the cells upon the original plans and specifications, this architect feels compelled to ignore the testimony of William Johnston, John L. Grant, and Peter McCubbin, all reputable and experienced mechanics in stone work, and each of them lately in the employment of the State in the construction of the prison. He was unable to base his estimates of the cost of this branch of the work upon "the different statements deduced from the testimony of the several witnesses," but was compelled to rely upon the reports of American, English, and French engineers upon the subject of how much rock can be quarried by one man in a day.

He says:

"The statements of these gentlemen are in striking contrast with each other, and also with the published experience of some of the best American, French, and English engineers whose maximum amount of stone allotted to be quarried by one man is eight tons; minimum five tons per day.

"Therefore, allowing 13 feet to the ton, would render from 65 to 104 feet as a day's work. These results are based on experience in solid bowlder quarries, and not like the first quarry used in connection with the Folsom Prison, which is termed a sheet or laminated quarry, offering much greater facilities for the easy abstraction of dimension stone. My own experience in quarrying convinces me that a man can turn out from 30 to 75 feet per day. * * * Under these circumstances I have maintained a basis of 34 cubic feet as a day's work."

Mr. Corlett means to say, of course, that the statements, of the engineers to whom he refers, relate to the amount of *dimension* granite that a man will quarry in a day. Did these statements refer to any other kind of stone than granite, or to granite in any other form than dimension stone, there would be no more pertinency in referring to them than there would be in referring to any statements they may have made about the number of cubic feet of sand a man will shovel in a day. Mr. Corlett certainly would not have been so disingenuous, as to have quoted these statements in the connection in which he did, unless their authors intended them as statements of the amount, according to their experience, of *dimension granite* a man would quarry in a day.

Mr. Corlett has not informed us where or in what reports these statements may be found. We must, therefore, take them as he has given them to us, and examine them without further light than that furnished by his own report.

It seems the smallest number of cubic feet which these engineers

allot as the product of a day's work by a quarryman is sixty-five, and the largest one hundred and four.

Mr. Corlett accompanied his report by a sort of key, which unlocks all the mysteries of that document. From this key we learn that if a quarryman's wages are two dollars and fifty cents per day, the other expenses incident to quarrying, such as help, powder, fuse, sharpening tools, and other items, will run the cost of quarrying the stone which the quarryman will take out up to \$3 39. Hence, if a quarryman, whose wages are \$2 50 per day, quarries 65 feet of stone, the cost of quarrying such stone will be \$3 39, or $5\frac{1}{10}$ cents per cubic foot; and if he quarries 104 cubic feet, the cost of quarrying it will be \$3 39, or $3\frac{1}{5}$ cents per cubic foot. Thus, according to "the best American, French, and English engineers," it is worth, when quarrymen's wages are \$2 50 per day, only from $3\frac{1}{5}$ cents to $5\frac{1}{10}$ cents per cubic foot to quarry dimension granite; furthermore, it is only worth these figures to quarry such stone from "solid bowlder quarries," from which it is much harder to take dimension stone than it is from the "sheet or laminated quarry" at Folsom.

But, notwithstanding the high character of these engineers, they received no more consideration from Mr. Corlett than did Mr. Johnston, Mr. Grant, and Mr. McCubben, who had testified before the committee. In determining what it ought to have cost to quarry stone to build the Folsom Branch Prison, he discarded with equal impartiality the statements of "the best American, French, and English engineers" as to the cost of quarrying stone from "solid bowlder quarries," and the testimony of the quarrymen who had worked in the Folsom quarry, as to what it cost to take stone from that quarry. The engineers placed the cost of quarrying from "solid bowlder quarries" at from $3\frac{1}{5}$ cents to $5\frac{1}{10}$ cents per cubic foot. Grant and McCubben, both of whom had worked in the "sheet or laminated" quarry at Folsom, placed the cost of taking stone therefrom at from 40 cents to 75 cents per cubic foot.

In this conflict of statement between the engineers on the one side and the quarrymen on the other, as to the cost of quarrying dimension stone, what does Corlett do? Does he side with the engineers against the quarrymen? By no means. Does he then join the quarrymen against the engineers? Not at all. What then does he do? He falls back on his own experience in quarrying—in his oral testimony he said he had been a time-keeper in a quarry in Belfast, Ireland, when a mere boy—and fixes what the cost for quarrying dimension stone for the prison should have been at ten cents per cubic foot. Perhaps this sum for quarrying was a fair compromise between the figures established for such work by "the experience of the best American, French, and English engineers" on the one side, and those indicated by the experience of the quarrymen who had actually taken rock from the Folsom quarry on the other. It will be observed that the ten cents per cubic foot, which he allows for quarrying dimension stone from the easily worked "sheet or laminated quarry" at Folsom is *from a little less than twice to more than three times as much* as the statements of the engineers establish as the cost of quarrying such stone from the more difficult to work, "solid bowlder quarries;" also, on the other hand, that it is only from *one-fourth* to *one-seventh* as much as those who had worked in the Folsom quarry, testified that it cost to take dimension stone from it.

But we confess we are at a loss to understand why Mr. Corlett

should have invoked the authority of the "best engineers" of three of the most advanced nations in engineering science as to the cost of quarrying dimension granite, and then have treated their statements as utterly worthless. If Corlett has correctly quoted those whom he is pleased to call "the best American, French, and English engineers," they are responsible for the statement that dimension granite may be quarried from "solid bowlder quarries" at from three and one-fifth cents to five and one-tenth cents per cubic foot when quarrying wages are $2 50 per day. Of course we regard any such statement as the very acme of absurdity, and consequently we are compelled to conclude that Mr. Corlett must have made a mistake in quoting these engineers. He himself admits his mistake in assuming the cost of quarrying to be ten cents per cubic foot, when the statements attributed to them place it at from less than a third to half of that amount.

Since Mr. Corlett made his report, G. Griffith, J. N. Taylor, and William Cook have testified before the committee in relation to the cost of quarrying dimension granite at the quarries at Penryn, Rocklin, and Folsom. Mr. Griffith and Mr. Taylor have testified also touching the cost of cutting stone respectively at Penryn and Rocklin.

Mr. Griffith is a quarryman and stone-cutter by trade; has been engaged in the granite business in this State since 1853, and at Penryn, in Placer County, since 1864. He employs from 50 to 200 men in quarrying and cutting granite, as the exigencies of the market demand. His appliances for quarrying are of the most complete and perfect character, so that the labor of all quarrymen employed is utilized to the best possible advantage. He ought to be able to quarry granite at a less cost, and no doubt does quarry it at a less cost, than any other person in the State. He testified that he could not quarry dimension granite for less than 50 cents per cubic foot.

I. N. Taylor is also a quarryman and stone-cutter by trade, and has been engaged in quarrying and cutting granite at Rocklin, Placer County, for the markets of the State, for about ten years. He does not carry on so extensive a business as Mr. Griffith. He thinks the Rocklin granite more easily quarried and worked than the Folsom. He testified that it cost him, on the average, to quarry dimension granite in the Rocklin quarry, about 75 cents per cubic foot.

William Cook has been engaged in quarrying granite near the site of the Folsom Branch Prison, chiefly for the San Francisco market, for about fourteen years. Some years ago he had a contract for 4,000 feet of dimension stone with which to build a vault in San Francisco; the stone to be taken from the Natoma Ditch Company's quarry, located just near the Branch Prison. He testified that it cost him 74 cents per cubic foot to quarry this lot of stone. Also, that his own quarry was more easy to work than that of the Natoma Ditch Company; that he formerly received $1 50 per cubic foot for dimension granite in San Francisco; that the price had now fallen to $1 20 per cubic foot; that it cost to ship to San Francisco about 50 cents per cubic foot; and that, at this latter price, it would not pay, and he had, in consequence, stopped work in his quarry.

These gentlemen have been engaged in quarrying granite for the market for fourteen to fifteen years, and ought to be able to testify as to the cost of quarrying it. Moreover, their testimony must, in the very nature of the case, be the best that can be had on the subject; and, being free from all suspicion even of bias, ought to be accepted as conclusive of the whole subject.

Now, there was in Jordan's contract, in round numbers, according to the architect's segregation, 114,000 cubic feet of dimension stone. To quarry this stone, it would cost:

According to Griffith's estimate	$57,000 00
According to Corlett's estimate	11,400 00
Difference	$45,600 00
According to Taylor's estimate	$85,500 00
According to Corlett's testimony	11,400 00
Difference	$74,100 00

Cook's testimony would give the same result, substantially as Taylor's. Let it be remembered that these gentlemen testified in relation to a business which they themselves had been carrying on, severally, from ten to fifteen years, and that they could have had no motive to testify to other than the truth.

As already stated, both Griffith and Taylor testified concerning the cost of peine-hammering stone from their respective quarries.

It may be stated here that the specifications accompanying the Jordan contract call for *first* class peine-hammered work.

Griffith testified that it cost forty cents per superficial foot to peine-hammer stone from his quarry. He explained that it cost more than it did to peine-hammer stone from the Rocklin quarry, because it came from the quarry rougher. He expressed the opinion that the Folsom granite was about the same to cut as the Penryn.

Taylor testified that it cost thirty-five cents per superficial foot to peine-hammer first class Rocklin granite. The cheapest he ever had done—second class, and very rough—cost twenty-five cents per superficial foot. These prices were exclusive of the cost of tools, keeping them sharp, etc.

Robert Orford, of San Francisco, a stone-cutter by trade, and a competent mechanic in all branches of stone masonry, testified that he made an estimate on the stone work of the Folsom Branch Prison for Dennis Jordan just prior to the latter's putting in his bid to do such work, and that he estimated the peine-hammering on the work required by the specifications at forty cents per superficial foot.

Corlett, in making his estimate of the cost of cutting the stone in the cells, placed the price of cutting the faces, beds, and joints of the walls at fifteen cents per superficial foot all round, the price for cutting the surface of the floors at twenty cents, and the joints of the floors at ten cents per superficial foot.

McHenry testified that when the stone-cutters were cutting at the above prices, the architect condemned much of the work as not coming up to the requirements of the specifications. He then, on the architect's finding fault with the cutting, caused the work to be done better, till it cost twenty and twenty-five cents more a superficial foot than it had done at the start.

John Lee, a thoroughly competent expert in all classes of masonry, and who now has the contract for building the Mark Hopkins vault, testified, after examining the work and the specifications, that none of the work at the prison was as good as called for by the specifications.

On the basis of the prices for cutting, above named, Corlett estimated that the cost of cutting the stone for a cell should have been

$118 69. In the light of the testimony above adduced, however, there can be no question that to have cut the cells anywhere near as well as the specifications required would have cost double that sum, or $237 each.

On what it cost to set a dimension stone cell not much testimony was taken, and no one testified on that point who could be regarded as an expert in that kind of work. Grant thought it could not have cost less than $45 to set a cell. William Johnston estimated the cost at $38 60. Corlett says it should have been done for $27. Johnston's estimate is probably about right, but, if out of the way at all, too low.

There are in the cells, according to the architect's segregation, 100,200 feet of dimension stone.

The stonework of the cells, according to the testimony above stated, would have cost:

Quarrying at 50 cents per foot, as per Griffith	$50,100 00
Cutting, at $237 per cell	77,736 00
Setting, at $38 per cell	12,464 00
Cost of stone work of cells	$140,300 00
Corlett says they should have cost	63,235 62
Difference	$77,064 38

Or, if we take as the cost of quarrying, 75 cents per cubic foot, as at the Rocklin and Folsom quarries, we have:

Quarrying	$75,150 00
Cutting	77,736 00
Setting	12,464 00
Cost of stone work of cells	$165,350 00
Corlett says they should have cost	63,235 62
Difference	$102,114 38

Thus, does it appear, from the testimony as to what it costs to quarry and cut dimension granite from the quarries at Penryn, Rocklin, and Folsom, of the very men who have been engaged in quarrying and cutting stone from these quarries for periods of ten to fifteen years last past, that the estimate of Corlett, in his report, of what the stone work of the cells alone should have cost, is from $77,000 to $102,000 out of the way.

It does not appear that Mr. Corlett, though an architect by profession, has any special qualifications for enlightening the committee upon the questions submitted to him.

His opinions, as we have before intimated, upon the character of the testimony, especially with his limited acquaintance with that testimony, are entitled to no consideration whatever. It may also be observed that his report bears internal evidence of a desire to depreciate the services of William Johnston in a branch of work in which the latter is clearly better qualified than his detractor.

He indulges this disposition in such remarks as these: "In this work the artificer seems to have been gradually losing all interest in his work." And again: "As a general rule, mechanics improve by practice; but in this case the rule proves the exception, for the last work done in masonry is decidedly the most inferior." In regard to these flippant and ill-natured criticisms, we have to say: They are not entitled to a place in any proper report, and, so far as the com-

mittee are able to judge from the testimony in the case, they are altogether without foundation.

It is proper to add that Mr. Corlett came again before the committee and produced a book, entitled "Trautwine's Engineer's Pocket-book," as the American authority to which he had referred.

Upon consulting this book, we find the cost of quarrying dimension stone referred to in but one place, and in a chapter on stone work, under the head of "Cost of Quarrying Stone." In order that there may be no misunderstanding, and for the purpose of showing that Mr. Corlett either does not understand or misrepresents the authority, we quote, from page 311 of the work, all that is said on the subject:

"After the preliminary expenses of purchasing the site of a good quarry, cleaning off the surface earth and disintegrated top rock, and providing the necessary tools, trucks, cranes, etc., the total net expenses for *getting out* the rough stone for masonry, per cubic yard, ready for delivery, may be roughly approximated thus: Stone of such size as two men can readily lift, measured *in piles*, will cost about as much as from one-fourth to one-half the daily wages of a quarry laborer;[1] large stones, ranging from one-half to one cubic yard each, got out by blasting, from one to two daily wages per cubic yard; large stones, ranging from one to one and one-half cubic yards each, in which most of the work must be done by wedges, in order that the individual stones shall come out in tolerably regular shape, and conform to stipulated dimensions, from two to four daily wages per cubic yard. The smaller prices are low for sandstone, while the higher ones are high for granite. Under ordinary circumstances, about one and one-third cubic yards of good sandstone can be quarried at the same cost as one of granite; or, in other words, calling the cost of granite one, that of sandstone will be three-fourths; so that the means of the foregoing limits may be regarded as rather full prices for sandstone, rather scant ones for granite, and about fair for limestone or marble."

According to this book, it will be seen that it requires in *wages alone*, which is not more than 70 per cent. of the expense, the labor of something over that of three men to produce 27 cubic feet per day of rough dimension stone, of the sizes required for the cells of the Branch Prison; in other words, less than 9 cubic feet per day per man instead of 34 feet.

In other words, according to this American engineer, whom Mr. Corlett calls on to do service in floating his report, it costs the wages of from 3 to 4 quarrymen to quarry a cubic yard of dimension granite—that is, 27 cubic feet. As a rule, he says, it will cost a little more than the wages of three quarrymen, and a little less than the wages of four. The wages of these quarrymen, at \$2 50 each, are \$7 50; and of four, \$10. If we take the wages of three quarrymen, as the cost of quarrying 27 feet of stone, the cost per foot will be 28 cents; and if we take the wages of four, the cost per foot will be 37.4 cents. Now, according to the rule laid down by this author, the cost of quarrying dimension granite should range between 28 cents and 37.4 cents per cubic foot, when the wages of a quarryman are \$2 50 per day. Will Mr. Corlett tell us who the American engineer is who fixes the cost of quarrying dimension granite at $3\frac{1}{5}$ cents to $5\frac{1}{10}$ cents per cubic

foot? And Mr. Corlett having, in his oral testimony, given the committee to understand that "Trautwine's Engineer's Pocket-book" was his American authority on the cost of quarrying stone, will he tell us why he did not take, as the basis for the estimates in his report, the cost of quarrying granite, which would have resulted from the application of Trautwine's rule, instead of an arbitrary sum, only one-third of such cost? In other words, why did he assume that the quarrying should have been done for 10 cents per cubic foot, when the authority on which he proposed to rely placed its cost at from 28 cents to 37.4 cents per cubic foot?

In support of his statements Mr. Corlett did not read form Traütwine's book the passage above quoted, but did read from a note at the bottom of page 312 a reference to the construction of the Bunker Hill Monument, during the period from 1825 to 1845. This note is as follows:

"The large blocks of granite for the Bunker Hill Monument, at Boston, averaging two cubic yards each, were quarried by wedging, and delivered at the site of the monument at a net actual cost of $5 40 per cubic yard to the Monument Association, from a quarry opened by themselves for the purpose. The association received no profit, their services being voluntary. The average contract offered for the same were $24 30. The actual cost of getting out the rough blocks at the quarry was $2 70; loading upon trucks at quarry, about 15 cents; transportation, eight miles by railway and common road, $2 55; total, $5 40. In 1825 to 1845 common unskilled labor averaging $1 per day."

From this it appears the actual cost of getting out the rough blocks at the quarry was $2 70 per cubic yard, or ten cents per cubic foot. Wages, however, were $1 per day. Other expenses were, no doubt, proportionately low. Ten cents per foot, when wages are $1 per day, are the equivalent of 25 cents per foot when wages are $2 50 per day. As the quarrying for this monument extended through a period of twenty years, the appliances for doing all the work were, no doubt, of the most complete and perfect character, so that all labor employed was utilized to the greatest advantage, and produced the maximum of results.

Upon such testimony as this, a witness claiming to be an architect, but confessing to no experience as a quarryman, stone-mason, or stone-cutter; and to no knowledge derived from superintendence of either kinds of work in the United States, seeks to overthrow the direct and certain testimony of such quarrymen as G. Griffith, John N. Taylor, Wm. Cook, Peter McCubbin, and others.

The estimate of this expert of the cost of the stone work of the rubble cells is quite as loose and unreliable as his estimate upon those portions of the work already referred to. This looseness and unreliability, it is not much to say, is carried to the point of being simply absurd.

Sixty-six dollars is his estimate of the total cost of the stone work per cell. This sum is really but little more than the actual and necessary cost of quarrying and setting the stones used for the tops or roof-covering of the upper tier of these cells, in each one of which tops there are sixty cubic feet of granite slabs. The cost of quarrying, moving, and setting these stones could not have been less than

fifty dollars for each cell in the upper tier. These slabs are each eight feet long by from two to five feet wide, and from ten to fourteen inches thick, and weigh from two to five tons each. John Lee, an acknowledged expert in all kinds of stone masonry, after examining the cells, testified that the cost of the rubble walls and the fronts of the rubble cells (not counting the stone tops of the upper tier), would be $167 65.

The stone work of all the rubble cells, under what the committee believe to have been able and economical management, actually cost (averaging the lower tier which have iron tops, with the upper tier which have the stone tops), $167 19 each. The iron floors, which form the floors of the upper tier and the tops of the lower tier, cost $44 75 each.

By adding this, it places the average cost of the rubble cells as they stand, without the floors of the lower tier being laid, at $191 each. By adding the stone tops and the iron floors to John Lee's estimate, the average cost would be $215 02.

After a consideration of the whole subject, the committee deem it necessary only to state the following general conclusions and recommendations:

First—The prison at San Quentin is insufficient for the proper accommodation, government, and discipline of the number of prisoners now confined therein.

Second—That with an appropriation of about $40,000, the Folsom Branch Prison can at an early day be put in proper condition for the reception, government, and discipline of about 500 prisoners, after which the San Quentin Prison, with its present accommodations, and its number of prisoners reduced to about 1,000, will be in a favorable condition for good management, and perhaps for making available the labor of the prisoners.

Third—That it appears reasonaby probable that the prisoners at the Branch Prison can be employed with advantage in the production from the quarries belonging to the State at that place (which are inexhaustible in quantity, and superior in quality) of granite blocks of all kinds for building and paving purposes.

Fourth—That the State has already invested in the construction of said Branch Prison $295,000, in addition to which the State owes as a consideration for the purchase of the quarries and land (483 acres), the sum of $15,000 in prison labor, at fifty cents per day. And in addition to this, in pursuance of the Act of 1878, providing for the completion of the Branch Prison, the State, in June 1878, entered into a contract with a responsible party, secured on his part by bonds, according to law, for the employment at the Branch Prison of 350 convicts, at fifty cents per day for each convict, for the term of five years, which contract is preserved by the Constitution.

That these alone are strong considerations against further delay in carrying out the work.

We therefore recommend the appropriation of the sum of $40,000 for the purpose of completing said Branch Prison.

REPORT

OF THE

JOINT STATE PRISON COMMITTEE

AS TO THE

Management of the Prison at San Quentin,

AND THE CONSTRUCTION OF THE

BRANCH PRISON AT FOLSOM.

JOINT STATE PRISON COMMITTEE.

SENATORS:

Johnson, Kane, Lampson, Langford, Moreland, Nye, Sears, and Watson.

ASSEMBLYMEN:

Brooks, Carr of Sacramento, Estey, Lane, Leach, Maguire, and Tyler.

REPORT.

Mr. President: The State Prison Committee of the Senate and Assembly, acting in concert with each other, have visited the State Prison at San Quentin and the Branch Prison at Folsom, and have made a thorough examination and inspection of the same.

SAN QUENTIN.

As to the prison at San Quentin, we found everything in complete order, the prisoners well fed and well taken care of, and the whole prison matters therein conducted in a perfectly satisfactory manner. We have also examined the accounts of the prison, and find them correct in every respect, so far as we have been able to judge, and the matter set forth in the report of the Resident Director, Honorable James A. Johnson, in all respects true, and to which we refer for a detailed statement of the condition of the prison. Upon inquiry of a large number of the prisoners, we found them contented and perfectly satisfied with their treatment at the hands of the officers, all of them stating that no one had ever been punished there to their knowledge who did not deserve it. We found it to be the universal sentiment of officers, contractors, and prisoners, that the "Goodwin Act," so-called, had had a most beneficial effect upon the government of the prison, giving the prisoners such an incentive to good conduct that a breach of the rules of the prison now seldom occurs. We found, however, the prison to be very much crowded, and the extension of the cell facilities at San Quentin, or other provision for the disposal of a large number of the prisoners, to be an absolute necessity. We found in one of the cell buildings seven large rooms on the ground floor in each of which are confined between 30 and 40 prisoners. We earnestly recommend to the State Prison Directors the alteration of said building, and the building of separate cells. We believe it would promote the welfare of the prison and prisoners if each prisoner could have a separate cell. We found upon examination that the building used as the officers' quarters, at the entrance of the prison, was hardly in a habitable condition, and we advise that it should be torn down and another building erected in its place. We found, also, that the walls surrounding the prison are in need of repair, that the mortar, to the depth of some inches, has gradually slacked and come out, and that the filling in and plastering of the entire wall is a necessity. We found that, from time to time, heretofore, parties temporarily connected with the prison have been allowed to erect buildings upon the prison grounds for the convenience of their families, and when they left there, were permitted to sell the same to others who took their places. We believe that those houses and buildings ought to be under the entire control of the Directors of the prison; and while the owners thereof have no legal claim to such houses (and if the State so chose it could take possession of the same), yet we think the parties have an equitable claim against the State for the fair value of said buildings, and we would recommend an appropriation sufficient to enable the Directors to purchase the same. Your committee also found that the clay on the lands belonging to the State, near the

prison, used for making brick, have been exhausted, and for that reason no bricks were manufactured last season. There is, however, plenty of land adjoining the prison grounds for sale containing clay suitable for that purpose, and we recommend an appropriation for the purchase of the same.

PRISON DISCIPLINE.

From the best information gained and inquiries made by your committee, we are of the opinion that the prison, to be of any benefit as a reformatory institution, should consist of three compartments, in one of which should be kept the hardened criminals, in another the first-timers, and in another the young men and boys, and that the several classes should be allowed to communicate with each other as little as possible. We think there should be a piece of land on the north of the prison at San Quentin, consisting of about four acres, and another on the west of about the same size, inclosed. We find upon investigation that four acres on the north could be inclosed and a building erected containing 200 iron cells therein at a cost of about $80,000, and another on the west for the same price.

We find that the building, with 200 cells, the whole (building and cells) of brick, can be constructed there at a cost to the State of from $10,000 to $12,000, and a brick building with 200 iron cells at a cost of $35,000.

PRISON LABOR.

Inasmuch as the Constitution of the State requires that after the 1st of January, 1882, no prison labor can be let out by contract, thereby necessitating the adoption of some plan by which the labor of the convicts may be utilized to the best advantage, rendering it necessary that a variety of manufactures shall be conducted on behalf of the State, that it would be to the best interest of the State that all of the prisoners should be together, so that each one might be worked to the best advantage in the employment with which he is most familiar.

From the best information we can obtain, we believe that were all the prisoners kept at San Quentin within the present and the two other inclosures heretofore spoken of, it would require no more officers to govern the prison, and require only an increase of from twenty to twenty-five per cent. in the guards of the prison; and we think it a very great mistake on behalf of the State that the Branch Prison at Folsom was ever established, as it requires an entire new set of officers, and more guards to guard five or six hundred men to be utilized at work there than it would at San Quentin, inasmuch as the grounds at Folsom, inside the contemplated prison yard, will be much greater in extent than at San Quentin, and very broken and hilly, rendering it impossible for one guard to see to any great distance.

THE BRANCH PRISON AT FOLSOM.

After an examination of the Branch Prison at Folsom, and finding that the appropriation had been exhausted, and that it would take some $40,000 more to complete the prison so as to be inhabitable, and finding that the same have not been constructed in accordance with the plans and specifications that had been adopted, your committee came to the conclusion that it was their duty to hold an investigation

in regard to the building of said prison, and in making such investigation have examined a large number of witnesses, and employed an expert to make a thorough examination and report thereon, and whose report is hereto attached. We find that there was available at the close of the session of the Legislature two years ago the sum of $205,000 for the completion of the Branch Prison. We find that subsequently three individuals or firms put in bids for the completion of said building in accordance with the plans and specifications of the architect, Mr. Bennett, which plans were a modification of the original ones drawn by Mr. Ball. Messrs. Hughes & Dudgeon offered to complete the building, in accordance with the plans and specifications, for $220,000; Mr. Livermore offered to complete the building for the sum of $212,000; and Dennis Jordan offered to complete the building for $161,500, which, being the lowest bid, was accepted by the Board of Directors, and he entered into a contract and gave bonds for the completion of the building at that price. At the time of making his bid the language of the specifications was, that the stone to be put into the cells should be "well hammered." When the bids were opened and the contract awarded to him, and upon its being represented to him that such terms might be construed to mean anything or nothing, he consented to the change of the specifications so as to read that the stone should be "peine-hammered." We find from the testimony that *peine-hammered* work is of very different kinds of grades, the best being worth some forty cents per superficial foot, and the poorest about ten cents, so that after the alteration of the plans, inasmuch as the work was to be peine-hammered, *and to the satisfaction of the architect*, it placed it in his power, by a strained or unfair construction of the specifications, to render it almost impossible for Mr. Jordan to finish his contract in accordance with the terms, as he understood them. We find that for some reason or other the architect seemed disposed to put obstacles in the way of Mr. Jordan in the finishing of the contract, often condemning work and requiring it to be removed that had been accepted by the Superintendent, Mr. Duncan, and he often stated to the men working for Jordan that there would not be money enough coming to him, Jordan, to pay the men their wages at the end of the month, and telling them at the same time that it would be better for them when Jordan should cease work and the Directors take the finishing of the work into their own hands. To such an extent was this carried that Mr. Beck, who seems to have been perfectly just and fair toward Mr. Jordan, stated that he at times was forced to place himself in the position of seeming to act as the friend of Mr. Jordan in the contest between him and the architect. We find, also, that the architect, from month to month, kept back in the estimates of the amount of work done money that should have been allowed and paid to him at the end of each month when the progress estimates were made. We find from the testimony offered of those who had entered into contracts with Mr. Jordan for the performance of work, and from the report of the expert, Mr. Curlett, that if the architect had put a reasonable construction on the specifications, and the money had been paid as it was earned, and if he had not tried to make the men discontented and afraid they would not get their pay, Jordan would probably have been enabled to complete his contract for the amount of $161,500, and possibly leaving him a profit on the job. Although, as it appears from the evidence, Mr. Jordan had invested some $18,000 of his own money in the job,

owing to the causes heretofore mentioned, he got behindhand in the payment of his workmen and other expenses, and his tools were attached, and he was unable to proceed with his work. While in that condition, and on the 13th of May, 1879, a requisition was made upon him by the Board of Directors in these words:

It was ordered that Dennis Jordan, contractor for the building of the Folsom Branch State Prison, be required to place on the said work, in addition to the 150 men required to be placed thereon by an order of date April 1st, 1879, and keep continuously thereon, the following number of mechanics and laborers, to wit:

75 stone-cutters.
50 quarrymen.
72 stone-masons.
28 tenders.
6 blacksmiths.
10 general laborers.

And to procure the following material, to wit:

500 barrels of Portland cement.
100 barrels Rosendale cement.
500 barrels lime.
500 cubic yards sand.
6,000 pounds steel (including hammers).
500 pounds plugs and feathers.
1,000,000 bricks.
10 tons Cumberland coal.
3 dozen blacksmiths' files.
3 mules.
2 one-inch Norway iron chains, 18 feet long.
4 three-fourths-inch Norway iron chains, 15 feet long.
8 derricks.
8 five-eight-inch Norway iron chains, 12 feet long.
2 bundles five-eighth Norway iron.
12 bars three-fourths Norway iron.
2 coils four and one-half-inch Manilla rope.
2 coils four-inch Manilla rope.
3 sets blocks, 12 or 14 inches.
100 kegs assorted nails.
200 kegs blasting powder.
1,000 feet fuse.
10 sets blacksmiths' tools, forges, etc.
175,000 feet lumber and sufficient mill work.

It appears from the testimony that the architect and Governor Irwin were the prime movers in the making of such requisition, and that many of the things directed to be procured *at once* would not be required for months afterwards and until near the completion of the work, and Governor Irwin himself stated that when he made the requisition *he did not expect that Mr. Jordan could fulfill it;* that he thought it was *impossible* for Mr. Jordan to comply with the requisition. By the terms of the contract, the contractor was to have fifteen days from the making of any such requisition in which to comply

with its terms, but notwithstanding it appears by the records of the Board of Prison Directors that on May 19th, 1879, six days after the requisition was made and before the work came under the control of the Directors, the Board employed Wm. Johnson as foreman of the work at the prison, at a salary of $200 per month. It appears, also, from the testimony of Governor Irwin and Mr. Duncan, that within a few days after the making of this requisition, Governor Irwin instructed Mr. Duncan to procure everything that was necessary for continuing the work of Mr. Livermore, and that as soon as the construction of the prison came into the hands of the State that he would be reimbursed, which was subsequently done. That before the fifteen days had elapsed in which Mr. Jordan was to comply with the requisition under the contract, several of the workmen were taken off the quarry near the prison and put to work down upon the river in a granite quarry, in which the granite was much harder than that upon the hill near the prison, and in the quarry owned by the Natoma Water and Mining Company, on the line of their proposed canal. The requisition not having been complied with by Mr. Jordan, the State Prison Directors resumed the control of the work and proceeded towards the completion of the same. The State continued the work from May until August in accordance with the plans and specifications of Mr. Bennett, when, finding that the $205,000 would not come anywhere near completing the job, Governor Irwin directed the cells, instead of being built of dimension stone peine-hammered, to be constructed of rubble work, at a saving to the State in the cost of construction of the number of cells then remaining to be constructed, as he said, of $75,000. This change, we find, was not made upon recommendation of the architect, but by Governor Irwin, consented to by Mr. Beck; Governor Irwin taking the whole responsibility, and being a lawyer and contending that he had a right to make the change under section five of an Act to regulate contracts on behalf of the State in relation to the erection of buildings, approved March 23d, 1876, which section is in these words:

SECTION 5. That no change of the plan or plans, descriptions, bills of materials, or specifications, which shall either increase or decrease the cost of said institution, asylum, building, or improvement, exceeding the sum of one thousand dollars shall be made or allowed, after they are once approved and filed with the Controller of State, as herein required, until such proposed change shall have received the approval of the Governor, State Treasurer, and Secretary of State; and when so approved, the plan or plans of such change, with the description thereof, and the specifications of the work and bills of material shall be filed with the Controller of State in the same manner as required before such change was made; and no allowance whatever shall be made for work performed or materials furnished under such change of plan or plans, or descriptions, or specifications, or bills of materials, unless before such labor is performed and materials furnished, a contract or contracts therefor is made in writing, which contract or contracts shall show distinctly the nature of such change, and shall be subject to all the conditions and provisions herein imposed upon the original contracts, and be subject also to the approval of the Attorney-General as hereinbefore provided; *provided*, that all changes in the contract exceeding $500 shall be by contracts in writing, with full specifications and estimates, and

shall become a part of the original contract, and shall be filed with the Controller of State with the original contract; *and provided further*, that the amount of such change in the contract, plans, descriptions, bills of materials, or specifications, shall not, in the aggregate, increase the cost of construction of said institution, asylum, building, or improvement, more than three per centum of the original contract price or cost.

Upon looking at the section we were of the opinion that it gave the Board no such right, and that the change was made without warrant of law, and made without consulting officially with the Attorney-General of the State. Whether it was good policy for such change to be made we are not prepared to say. But we deem it our duty to say that, in our opinion, it was a dangerous exercise of power. We find that several other changes were also made by the Board, and which renders the prison in its present state, if completed, unfit for occupation by prisoners; and if the same is completed, we would recommend that the changes be made, as indicated by the architect, Mr. Curlett, in his report hereto attached.

We find the whole appropriation of $205,000 has been exhausted, and a deficiency remaining of some thousands of dollars, besides the $18,000 put into the building by Mr. Jordan.

We find, also, from the estimates of Mr. Duncan, it will require about $38,000 more to complete the building. According to the testimony of Governor Irwin there was $75,000 in the cost of construction saved by the change of plans heretofore spoken of, making altogether $336,000 the cost of the completion of the building (with the saving by the changes), whereas the highest amount bid by any party was $220,000 for the completion of the whole, in accordance with the plans and specifications, being a difference of $116,000, which is only, perhaps, a fair illustration of the difference of cost to the people when work is performed by the State or by a private party. Of the moneys drawn for the completion of the Branch Prison at Folsom, after the taking possession of the same in May, we find that $89,837 77 were paid to the Directors upon their warrants. Upon examination of the pay-rolls, as kept at the prison, we find that very many men are credited with one and a quarter, one and a half, and in some instances as much as one and three-quarter day's work in each day.

We find, also, that in the month of June there were 53 men who signed the pay-roll with a cross; in July 64, in August 49, and in September 35, not one of whose signatures is witnessed by the signature of any one written near it, as required by law; and, therefore, there was no means of knowing whether the money was in fact paid to those men or not.

HEALTH AT FOLSOM.

Your committee find, from the testimony taken, that the location of the Branch Prison at Folsom is not a very healthy one. All the parties who worked there agree in the fact that there is a great deal of malaria there, and that it is necessary for all parties working there in the summer months to take a large amount of quinine to prevent fever. We find upon inspection of the pay-rolls that, of the number of men working there during the months of July, August, and September of last year, the average number of days' work performed by the different workmen in July was 14.6, in August 10.7, and in Sep-

tember 15.6 days in each month; and upon inquiry of those in charge why no more days' labor was performed by the workmen, we were informed that they did not know, unless it was on account of sickness.

Your committee found on the prison grounds, and near the Branch Prison at Folsom, a fine granite quarry, capable of furnishing all the granite that will be needed in the State of California for the next one hundred years, of good quality and easy to work. It appears from the testimony of Mr. Johnston, who has been at work there, that he would be able to furnish from the quarry, with one hundred and fifty ordinary men—free men—all the dimension granite that could be sold and used in the State of California for the next twenty years, reducing the price thirty-three and a third per cent. from what it is now. We are of the opinion that few, if any branches of business, other than the quarrying of granite, can be successfully prosecuted at that place with prison labor.

Under the Act of the Legislature of California entitled "An Act to provide for the completion of the Branch State Prison at Folsom," approved April 1st, 1878, it was provided, under section twelve, that the Act should be null and void unless the Prison Directors entered into a contract with some party before the 30th of June, 1878, to hire not less than 350 prisoners at a price not less than fifty cents per day, for five years, "to be worked upon the prison grounds." On the 29th day of June, 1878, H. G. Livermore entered into a contract with the Prison Directors to employ 350 prisoners upon the prison grounds for the period of five years, at the rate of fifty cents per day, and, at the same time, the Directors entered into a contract with him, giving him the sole and exclusive right to use the quarries on the prison grounds during the said five years. The policy of making such contracts might, we think, be safely questioned, but it is enough for us to know that the contract has been entered into by the State, and she is bound to fulfill her contract.

By the terms of the deed from the Natoma Water and Mining Company to the State, conveying to the State the land on which the Branch Prison at Folsom is situated, the State is to furnish to said Water and Mining Company fifteen thousand dollars worth of the labor of prisoners, at fifty cents per day, to work on the dam and canal of said company.

Such being the case, notwithstanding the unhealthiness of the location, and the fact that it is doubtful whether men can be used in any profitable employment at that place, except the 350 to be furnished Mr. Livermore, and the fifteen thousand dollars worth to the Natoma Water and Mining Company, the majority of your Joint Committee, consisting of twelve, out of the sixteen present, are of the opinion that it is for the best interests of the State that an appropriation of $40,000 should be made to complete the Branch Prison, to furnish the labor to Mr. Livermore and said company, as provided for in the contract of June, 1878, and the deed aforesaid, and to give to the said Branch Prison a fair trial.

Mr. Jordan claims that he has been unfairly treated, and thinks that we ought to make a recommendation for an appropriation in his favor; but your committee cannot view the matter in that light. If he, or any one else, has any just claim against the State, some provision should be made to give them an opportunity to maintain their rights in a Court of justice.

We find, upon examination, that there is a deficiency in the appropriation for the maintenance of the prison at San Quentin for the fiscal year of 1879-80—for the support of the prison—of about $51,000; that it will require for the support of the prison the next fiscal year, 1880-81, the sum of $180,000; for the building for the quarters of officers and guards at San Quentin, the sum of $20,000; to make provision for the lighting of the prison grounds and yard, the sum of $10,000; for the construction of the reformatory recommended by the Directors, the sum of $20,000; for the purchasing of buildings erected on the prison grounds, belonging to others, the sum of $10,000; and for the purchasing of machinery and material for manufacturing, under the direction of the Board of Directors, the sum of $250,000; for the repair of the present wall of the State Prison at San Quentin, the sum of $10,000; for the purchase of clay land, the sum of $15,000.

Your committee does not recommend the appropriation of any money for the inclosing of any additional ground at San Quentin, at the present term of the Legislature, for the reason that if the Branch Prison at Folsom is completed it will render it unnecessary for the present. We do not ask an appropriation for the running of the prison at Folsom, as the same cannot be completed for several months to come, and as the Directors have the right to use any money appropriated for the support of either prison. There will be funds sufficient to carry on both prisons from the time of the occupation of the Folsom prison until an appropriation can be made by the next Legislature.

The whole sum recommended by your committee, summed up, is as follows:

Deficiency for present fiscal year	$51,000
Maintaining prisons for next fiscal year	180,000
For machinery and manufacturing materials	250,000
Quarters for guards	20,000
Light for prison grounds	10,000
Reformatory	20,000
Purchasing buildings	10,000
Purchasing clay land	15,000
Repairing wall	10,000
Making altogether the sum of	$566,000

And we also recommend the passage of the bill introduced by Senator Johnson, in the Senate, appropriating $40,000 for the completion of the Branch State Prison at Folsom.

The instructions given to the expert, Mr. Curlett, with his report, are hereto attached and transmitted for the consideration of the Legislature.

All of which is respectfully submitted, together with the evidence.

B. J. WATSON,
Chairman of Senate Committee.

GEO. W. TYLER,
Chairman of Assembly Committee.

CHAS. L. ESTEY.
JAMES NELSON.

I concur as to the conclusion making appropriations.

S. G. NYE.
GROVE L. JOHNSON.

We, the undersigned, dissent from that part of the report recommending the appropriation of money for the completion of the Branch Prison at Folsom.

THOMAS KANE,
WILLIAM H. SEARS,
GEORGE W. TYLER.

Although I agree that the action of Governor Irwin, in making the requisition referred to in the report, and the changing of the plans, was irregular, and a dangerous precedent, yet I am satisfied that it was done with honest intentions. I also dissent from the conclusions as to the health at Folsom.

FRANK A. LEACH.

We dissent from any recommendation favorable to the enlargement of the San Quentin Prison, believing it not desirable from any standpoint of advantage to the State, but, on the contrary, would result in pecuniary loss and sanitary and reformatory damage, since the phrenological histories of all civilized countries show conclusively that herding great masses of criminals offers no compensating benefits for its certain evils. We do not think that more than a thousand prisoners should be confined in one place.

We are not prepared to say that Jordan could have completed his contract without loss, under any proper rulings by the architect; on the contrary, we are impressed with the view that his bid was at least forty thousand dollars too low. Nor can we accept the conclusion of the expert, Curlett, since his report bears internal evidences of his incompetency. We do not agree with that portion of the report which declares against Folsom for sanitary reasons, nor do we concur in the assertion that no branch of business other than granite quarrying can be successfully carried on at Folsom; nor do we concur in the opinion that "the policy may be safely questioned" of making a contract with H. G. Livermore for the employment of three hundred and fifty of our idle convicts for five years at fifty cents a day. We think there can be no question of the good policy of securing a certainty of two hundred and seventy-five thousand dollars for the labor of three hundred and fifty convicts within the next five years.

WILLIAM B. MAY,
M. LANE,
A. B. MAGUIRE,
SEYMOUR CARR.

NOTE.

It is due perhaps to myself and the House to say that the testimony in this investigation was taken by a sub-committee of the two committees, and that neither Hon. S. T. Nye, Hon. Grove L. Johnson, Hon. William B. May, Hon. M. Lane, Hon. A. B. Maguire, or Hon. Seymour Carr, heard very little of the testimony as taken, and their duties have been so onerous that they have not had time to read it since it was written out by the short-hand reporter.

Since writing the report, I understand ex-Governor Irwin takes some exceptions at being called a lawyer. In this I may have done him injustice. Finding he had not consulted officially with the Attorney-General before changing work on cells from "dimension

stone, peine-hammered," to rubble work, he was asked if he was a lawyer, and his reply was, "I have studied law." I inferred from his answer that he was a lawyer, but I wish here to correct the statement.

GEORGE W. TYLER,
Chairman Joint State Prison Committee.

Mr. William Curlett, Architect:

SIR: The Joint Committee of the Senate and Assembly on the State Prison desire you, as an expert, to proceed to Folsom, and:

First—Make a careful examination of the Branch State Prison building near that place, and furnish an estimate of what it would have cost to complete the cells and prison building according to plans and specifications under which the Jordan contract was let. You will be governed by the testimony as to cost under Jordan contract.

Second—Make an estimate showing the difference in cost between the manner of executing the work as per Jordan contract, and the present work as executed under the direction of the late State officials.

Third—Make an estimate of what it will cost to complete the building from now on, in accordance with the Bennett plans and specifications.

Fourth—Make such suggestions as, in your judgment, would be beneficial to the present building.

GEO. W. TYLER,
Chairman Joint Committee on State Prison.

To the Hon. G. W. Tyler, Chairman of the Joint Committee of the Senate and Assembly on the investigation of the State Prison at Folsom:

SIR: In compliance with your instructions of the 16th instant, I made a careful examination of the various plans and specifications of the Folsom State Prison, which were in the custody of the Controller, who kindly extended to me every facility for their inspection. After which, in company with Messrs. Duncan, Jordan, and Terrill, I proceeded to Folsom, and there carefully inspected all portions of the work completed, and also that in course of construction, and now respectfully submit a minutely prepared report, together with a correct estimate of what it would cost to complete the building under the Jordan contract, and what it will require to complete it as it now stands.

1. The exterior walls of the superstructure is a good specimen of strong, rough, coursed ashlar masonry, and very suitable for the purpose the building is intended.

Passing in through the heavy iron gate of the new approach building, which is in itself a good piece of workmanship. but the setting up and hinging is executed in no very creditable manner; apparently there has been some late changes in the masonry about this gate, the stones have been reset in bad mortar, showing an imperfect finish in conjunction with the old work, by partially leaving all the jamb stones loose, thereby permitting the gate to get out of plumb, and which cannot now be closed.

I then proceeded to inspect the cells, which I found constructed in the following manner: On the first floor there are 44 cells constructed of dimension stones peine-hammered, and one cell with floor and three sides of dimension stones, with the ceiling of boiler plate iron; also, one cell with floor and sides of dimension stones, with boiler-plated iron ceiling; and one cell with floor and about one-half of the walls of dimension stones, with iron ceiling as above; the remaining cells on this floor are constructed of rubble masonry, many of which are a rough specimen of wall building, caused by setting the stones without due regard to the preparation of beds or joints, much less the selection of stones, whereby the work could be closely jointed, as should have been in work of this character. The top course on these walls are generally constructed of small stones, which, in my judgment, is just the opposite to what should have been done. Whilst the mortar used in this portion of the work is deciedly of a very low grade, but apparently no limit to the quantity, which I do not consider adds much to the strength of the work.

The iron doors to these cells have, in a few cases, already got out of order, apparently from the fact that the stones which the hinges are secured to are too small and not properly anchored back.

Passing up the iron stairs to the second story I find forty-two cells constructed of dimension stones peine-hammered, and two cells with floor, roof, and one side of dimension stones. The remaining cells on this floor, like that of the first story, are constructed of rubble masonry; but in this work the artificer seems to have been gradually losing all interest in his work, for the walls and angles are constructed in many cases in a very rough manner, whilst some of these walls are topped out with exceedingly small stones—and in few cases are they built up to the ceiling, but some left with a piece of lumber partially supporting the heavy roof stone covering, which has in one or two cases split the top portion of side walls. The ceiling, or roof stones, which are left rough from the quarry, and in one or two instances the joints are left open, so that it would not be impossible to set fire to the roof timbers from the cells; and many of the joints are left from six to eight inches open on the under surface, narrowing up to the top, thereby leaving it a difficult task to properly fill these interstices, which could have been avoided had these stones received a rough jointing, and then placed with the widest face downward. If this had been done, any inequalities on the top surface could then have been filled up with coarse strong concrete.

As a general rule mechanics improve by practice, but in this case the rule proves the exception, for the last work done in masonry is decidedly the most inferior.

I would strongly recommend that all these cells that are built of rubble masonry have the joints of the same raked out and the surplus mortar cleaned off, and that the entire surface, including the vacuum in the ceilings, be plastered with a heavy coat of the best English Portland cement; also, to prepare the iron floors by giving them a heavy coat of asphaltum, to be succeeded by a layer of English felt, and ending with a second coat of asphaltum, and in such treatment allowing for a graded pitch to the doors.

The roof, or ceiling, covering these cells should have had more care bestowed upon its constructon, as the main roof over the entire building is constructed of no stronger materials than what are commonly used for a roof of a private residence.

As the lighting of the central corridor is very deficient, caused by a ⅞-inch redwood board ceiling obstructing the light, I would suggest the entire removal of said ceiling, and also the wood work between tops of cells and the roof, and this latter space walled up with rubble masonry, thus lessening the danger of escape from the second story cell galleries, which, under the present circumstances, would afford but imperfect resistance against a convict determined upon making an exit by the roof. I would further suggest that the iron bars in the ceiling over corridors be removed therefrom and reset at the skylight openings, forming guards to the same. And I would further state the necessity of connecting-bridges being built from the second story cell galleries, at each end thereof, for the convenience of the guard visiting both cell sections on the second floor, obviating the necessity of returning down stairs; also, that the angle stays supporting galleries over the stairs at each end of the building be removed, and in lieu thereof to support the said galleries by iron suspension rods from the roof, for, in the present condition, I consider the presence of the stays as an interruption to the headroom of the staircases. A small panel, with wicket in each of the cell doors, would greatly augment the ventilation and light of the same.

And finally, I would suggest that a change be made in the plasterer's specifications, substituting iron lath in place of wood for all the ceilings and stud partitions, and omit all furring on the outside walls, plastering the same with good strong mortar directly on the stone walls, thereby making this section of the building as near fireproof as possible. Prior to concluding this report, I desire to express my approval of the workmanlike manner in which the following branches of this work has been executed, namely: wrought iron work, plumbing, tinning, carpenter and joiner's work.

Subjoined is a detailed estimate for the completion of the building under the "Jordan contract":

Complete cost of one cell built of dimension stones		$191 44
Three hundred and twenty-eight cells, at $191 44 per cell	$62,792 32	
Outside and walls to cells	443 30	
		62,235 62
Approach building		4,031 84
Water-closet building		773 35
Cell building (outside walls)		3,182 45
Window in same		1,225 25
Front building, including chimneys		6,905 10
Jointing outside walls		500 00
Alterations in basement		934 00
Filling in windows		250 00
Flagging		7,522 00
Tinning, cast, and wrought iron work		28,500 00
Carpenter work		13,866 60
Plumbing		2,800 00
Plastering		3,100 00
Painting		2,800 00
Mantels		1,000 00
Total		$140,626 21

In the preparation of the foregoing estimate I have based my calculations on the different statements deduced from the testimony of the several witnesses, that portion of the testimony relating to the quarrying of the stone being given in such a vague and ambiguous manner as to preclude any value set on the same as a criterion for my calculations. The testimony of Messrs. Johnston, Grant, and

McCubben corroborates this statement in the facts that the former, when, in answer to the Chairman's question, said that he could, with 100 or 150 men, quarry enough stone to supply all the demand of the State, making the amount unlimited, and subsequently testified that a man could not quarry more than four feet per day. Mr. Grant testified that a man could quarry about fifteen feet per day, while Mr. McCubben stated that twelve feet was a day's work. The statements of these gentlemen are in striking contrast with each other, and also with the published experience of some of the best American, French, and English engineers, whose maximum amount of stone allotted to be quarried by one man is eight tons; minimum, five tons per day. Therefore, allowing thirteen feet to the ton, would render sixty-five to one hundred and four feet as a day's work. These results are based on the experience in solid bowlder quarries, and not like the first quarry used in connection with the Folsom Prison, which is what is termed a sheet or laminated quarry, offering much greater facilities for the easy abstraction of dimension stone. My own experience in quarries convinces me that a man can turn out from thirty to seventy-five feet per day. The conclusions which I think may be reasonably drawn from the foregoing statements and observations, will bear me out in my calculations, and, to be within the limits of a quarryman's capacity, under these circumstances I have maintained a basis of thirty-four cubic feet as a day's work.

Estimated cost of building one cell, in rubble masonry, as constructed by the State, $56.

Estimated cost of completing the building, from its present condition, including the following: cementing and plastering, painting, patent stone flooring, marble mantels, stone stairs, steam boiler and heater, water works and well, gas works and fixtures, mason work, and about 5,000 feet of boundary wall, $70,000.

Respectfully yours,

WILLIAM CURLETT, Architect.

P. S.—Mr. Jordan informed me that when he estimated on the work there were on the ground the following materials:

Cut stone, amounting to	$4,000 00
175 barrels of cement	525 00
Lime and sand	150 00
Total	$4,675 00

Also, that there has been a deduction from the original contract, for the iron work, amounting to $3,200.

ESTIMATE OF TWO CELLS.

Floors—First and second stories (each) 70.9=141.06 at 20 cents		$28 30
Door sills—Two door sills 9.6 at 20 cents		1 85
Floor joints—Floor joints in first and second floors, 72 feet, at 10 cents. (These joints are taken at 8 and 10 inches wide)		7 20
Ceiling joints—Joints in second story ceiling 25.3, at 10 cents. (These joints are taken at 10 inches wide)		2 50
Ceiling surface—Second story ceiling, 96 feet, at 10 cents		9 63
Main dividing partition wall—Surface of the main or partition wall, two stories, 128 feet, at 15 cents		19 20
Front walls—Surface walls, two stories, 128 feet, at 15 cents		19 20
Door rebates—Allowance for cutting extra on door rebates		10 00
Side walls—Surface of side walls, 272 feet, at 15 cents		40 80
Joints—Horizontal joints, front and back walls, two stories, 320 feet, at 15 cents		48 00
Horizontal joints in side walls (two stories), 170 feet, at 15 cents		25 50
Vertical joints in two cells, 168 feet, at 15 cents		25 20

SETTING STONES, ETC., IN TWO CELLS.

Masons—Three masons, one day, at $3 each	$9 00	
Laborers—Three laborers, one day	6 50	
Engines—Attendance one day, at $3	3 00	
Fuel for engines	1 00	
Hauling in stone from yard to building	4 00	
One stone-cutter, putting in clamps and eyes	3 50	
		$27 00
Two cells		54 00
		$291 38
Leveling—Leveling up under first floor and extra building around ventilators		7 00
Rubble—In center of partition wall to each cell	4 feet	
In front wall at level of first and second floors	40 feet	
Total	44 feet at 20 cents	8 80
Cement—Allowed three barrels of cement to two cells at $5		15 00
Sand, etc.—Sand and water for two cells		1 50
Cubic feet of dimension stone in front and back walls of two cells	392 feet	
Cubic feet in two floors and ceiling*	200 feet	
Total	592 feet at 10 cents	59 20
Total cost of two cells		$382 88
Cost of one cell		$191 44

The above estimated, at the following rates:

Quarryman—One hand-driller, at $2 50, will split thirty-four feet per day	$2 50
Sharpening tools for the same, etc.	22
Powder and fuse	12
Removing granite and debris, etc.	20
Hoisting expenses	15
Hauling stones to yard	20
Total	$3 39

End walls to cells—Outside end walls to cellars, 688 feet, at 15 cents	$103 20
Horizontal joints in the above, 1,147 feet, at 15 cents	172 05
Vertical joints in the above, 372 feet, at 15 cents	45 80
Beds of string courses (taken 10x16 inches), 143 feet, at 15 cents	21 45
Dimension of stone in end walls, 1,008 feet, at $5	100 80
Total	$443 30

* **NOTE.—Each floor is measured 8x10 feet + 10 inches thick.**

INAUGURAL ADDRESS

OF HIS EXCELLENCY,

GEORGE C. PERKINS,

GOVERNOR OF CALIFORNIA,

January 8th, 1880.

INAUGURAL ADDRESS.

Members of the Legislature and Fellow-citizens:

Grateful to Almighty God, and deeply impressed with the responsibilities I assume, I am here to comply with a custom which has properly prescribed that an incoming Chief Executive should briefly outline the policy by which his official conduct shall be controlled.

While adhering to those political principles held by the party that nominated me for the office, the duties of which I assume to-day, yet I should be remiss did I not make public recognition of the very cordial support I received from many who differed from me in mere political creeds. The representatives of those creeds, with others, hold membership in both branches of the Legislature, and their combined intelligence and wisdom I invoke in aid of judicious and wholesome legislation.

Steady prosperity and material advancement have attended the short life of this Commonwealth. To the ordinary sources of wealth, which give so much stability to business enterprises, have been added fabulous fortunes from the mines, ever inciting to industry and enterprise, and offering fields of operations adapted to the desires of the most moderate, as well as provocative of undertakings broad enough to tax the resources of the most skilled engineers and the boldest financial operators. The gain to the wealth of the world exceeds two hundred and fifty millions, and as a factor in the financial life of the nation it has served as a great balance-wheel in the monetary system. The natural results flowing from productions largely in excess of consumption are manifested in thriving cities and towns, in comfortable homes, in a large individual independence, in transportation facilities in pace, if not in advance, of the age, in complete educational facilities, and in all the accompaniments of an advanced and advancing civilization. These reflections should inspire us with gratitude to the Great Architect of the Universe, as well as impel us to exert ourselves to bring to perfection what has been so well begun.

The organic law, which for thirty years served as our sheet anchor, has been set aside by the people and a new one substituted. It shall receive from me a faithful interpretation and enforcement in spirit and letter. Whatever it possesses promotive of the public weal will become apparent by actual test, and if it contains concealed destructives they will soon be uncovered by the people. A conservative purpose should characterize legislation in pursuance of the new fundamental law, and the required alterations should be so wisely adjusted as to cause the least possible friction in the social and business systems. Sharing in the earnest desire of my able predecessor to put into immediate effect certain provisions of the new Constitu-

tion, and thereto prompted by the solicitation of eminent citizens, I united with Governor Irwin in the selection of three gentlemen to act as Commissioners in the preparation of such amendments to our present Codes and Statutes as would make them harmonize with the provisions of the new Constitution. The established reputation for learning and ability of the gentlemen thus selected, justifies me in commending to your consideration the results of their labors, which, it is confidently expected, will facilitate yours; and, if it is found that they have rendered a real public service, I feel confident that you will provide such compensation as shall be just.

However wise may be constitutions and laws, prosperity must spring from individual and associated effort, industry, intelligence, and economy; from strong hands and cultured brains working in harmony. Manual labor can accomplish little without intelligent direction, and mere intelligence is ineffective without the strong arm of labor to execute its designs. Capital can do absolutely nothing while depending upon itself alone. But capital, intelligence, and labor uniting, produce results beneficial to each of the trio, and add to the wealth and happiness of the community. One of the offices of government is to give encouragement and protection to labor and capital. The more thoroughly and entirely that government protects and encourages the use of labor and capital, the nearer does it approach to a state of perfection. I regard the relations of the working classes to their employers as among the most pregnant problems of the day. Also, that it is one of the highest duties of the State to so frame her laws as to tend to the intellectual and moral advancement of her laboring classes. One of the auxiliaries to their elevation is an avoidance of wealth centralization, with the attendant power. The smaller taxpayers complain that they are made to bear an undue proportion of the State burdens; that the wealthier classes are ingenious in inventing methods whereby their properties escape paying the just charges for its governmental protection, and that the laws favor the rich at the expense of the poor. I do not concede that all the complainings in these directions are well founded; but the fact that such sentiments find pregnant expression is sufficient to put us on diligent inquiry as to their foundation, and to impel us to seek and apply adequate remedies. But a wise distinction must be drawn between statutory protection of the laborer and utopian plans of dreamers that teach men that they can live without industry at the charge of the more wealthy and provident classes. He is an enemy to society who attempts to inculcate the doctrine that any one class owes any other class a living.

STATE PRISON.

By a wise provision of the new Constitution, the State penal institutions are to be placed under the sole control of a Board of Prison Commissioners, appointed by the Executive. After January first, eighteen hundred and eighty-two, the Constitution prohibits the contracting of prison labor, and then an additional responsibility will devolve upon the Prison Commission. We cannot too early turn our earnest attention to a consideration of the uses that can be advantageously made of convict labor, so as not to conflict with and degrade the free labor of the State. For the handling of our cereals alone, upwards of twenty-five million sacks are required annually,

besides large quantities for other purposes. Millions of dollars go abroad yearly for the purchase of these necessary articles. It must be that the diversified soil and climate of this State are able to produce the jute from which the burlap is made. Its manufacture is not difficult, nor is the requisite machinery complicated, though somewhat expensive. If the raw material can be grown in California, of which I have no doubt, its manufacture by convict labor would open a new industry to the husbandman, and its full development would cheapen the cost of the manufactured article to the agriculturist. Employment would be given to convict labor without coming into competition with free labor to any appreciable extent. If experiments should establish the impracticability of growing the raw material, then we should ask Congress to abolish the duty on raw jute to be manufactured at the State Prison. We have in the State but one factory for working up the crude material, and that is operated mainly by Chinese labor.

The near completion of the Branch Prison at Folsom will, in a measure, relieve the one at San Quentin, and with increase of room and facilities for working the convicts, progress may be made in making the prisons self-supporting, while it is hoped a system more reformatory in its character may be inaugurated.

AGRICULTURAL AND MINING INTERESTS.

Of the largely diversified interests of California, agriculture and mining are the principal sources of our prosperity and wealth. All cereals and fruits here yield most abundant harvests. The soil responds to man's industry and rewards his labors. Yet, ancient and honored as is agriculture, constant improvements are being made in its departments, and new discoveries augment the net gains. It is the duty of the State to foster the agricultural interest by providing for the dissemination of trustworthy information respecting her resources, the character and adaptations of her soils, so that the new-comer may enter upon his labors with an intelligent confidence in the result.

A progressive step has been taken during the past year at the University in the establishment of a garden of economic plants, in which a large number of growths proposed for culture in this State are being tested.

Still the science of agriculture in our State is yet in its infancy. The peculiarity of our soils, seasons, and climate makes the ripe experience of other countries unavailable to us in our methods of agriculture. An unskillful and unscientific agriculture will impoverish our soil, and eventually convert our fertile valleys into desolate wastes. The carefully collected experience of the older States, which constitute the literature of the science of agriculture, being unavailable to us, we are dependent upon self-instruction for what we now know, or have yet to learn, of the most scientific methods of field and orchard cultivation. The Bureau of Agriculture at the National Capital is a most valuable aid in the dissemination of intelligence on the subject of scientific agriculture, as that science may relate to the laws of production under the conditions existing in the great body of States in this Union. But the peculiarities of condition existing in this State call for the evolution of a special science of agriculture, and as a means to that end I most respectfully recom-

mend that, through our Congressional delegation at Washington, the Congress of the United States be memorialized to establish a branch of the National Bureau of Agriculture on the Pacific Coast.

Further, and appropriately in this connection, your attention is respectfully directed to the wise encouragement heretofore given by this State in the way of promoting a higher agriculture by stimulating annual exhibitions of the highest results of industry. This encouragement should be continued under the guarded restrictions of the Constitution of our State.

Mining, for a long time the principal pursuit of our people, is still one of the most active and profitable industries. Its importance to the State and to the nation cannot be overestimated or gainsaid; and it is not without pride that we point to the fact that, since the discovery of gold here, California alone has produced over one thousand two hundred and fifty million dollars, a sum that exceeds the aggregate productions of all the rest of the United States. As results are the measure of success, these many millions prove the importance, State and national, of the mining industry, and ought to relieve it of its supposed speculative character. There is a broad and well defined distinction between the legitimate California miner—the producer of these vast sums—and the stock speculator who deals in paper evidences of titles to supposed mining properties. While legitimate mining has accomplished so much for the State, it must be admitted that the State has not done all it ought to have done for mining. We provided for a State Geological Survey, which was barren of any useful results; and before its completion a School of Mines was founded at the University, the outfit of which has never been furnished, and its chair is vacant.

Is it not due to the mining interest that the results of the geological survey already paid for, compiled, and collected—such as are practical in their nature—be made public property, when no expense is entailed except that of their publication? What has been done we should have the benefit of.

DEBRIS.

In several sections of the State a conflict has arisen between the mining and agricultural interests in relation to the debris washed down by the rivers. The best interests of the State require that this most important and most delicate question should be settled upon some broad and comprehensive basis. The report of the Board of Engineers provided for by the last Legislature will doubtless furnish you with information in this connection.

IRRIGATION.

The important subject of irrigation, with special reference to the San Joaquin Valley, has been the topic of investigation by the State Engineer and his able corps, and it is expected that his report to the Legislature this session will present some data upon which may be based wise legislation.

FREIGHTS AND FARES.

The progress made in the construction of railroads during the past half century, the convenient facilities they furnish for travel and for the rapid interchange of commodities, have brought their relations

to the State into a prominence that cannot be ignored by those occupying, or who would occupy, official stations.

Transportation companies move the agricultural and manufactured productions of the world. Their growth has been so overshadowing that the earnest attention of the wisest statesmen of both hemispheres has been directed to the subject of governmental supervision. In some of the older States such supervision has been tried and abandoned. In others the experiment has met with approval, and has resulted in a better understanding between the public and the railway companies. In this State we have had two Commissions created by statutory enactments, and clothed with limited supervisory authority.

The railroad companies disputed the right of the State to interfere in their affairs, and this attitude undoubtedly tended to the adoption of the far-reaching provisions in the new Constitution intended to regulate and control transportation companies.

A Commission authorized by that instrument has been chosen by the people. Its powers are almost unlimited, and partake of the legislative, executive, and judicial. The wisdom of delegating such extraordinary powers to such limited numbers, is not open to discussion or challenge in this place. The people, with whom the power rested, have so decreed, and it remains for their servants to obey. Yet I trust that the Transportation Commissioners will not consider me as exceeding official courtesy, if I give expression to the hope that they will be able to effect a more harmonious relation between the transportation companies and the people whom they serve. Some of the constitutional provisions governing this subject are probably not self-executing, and will need legislation to give them the effect designed by their framers. I respectfully invite the attention of the Legislature to this subject, and recommend the passage of such laws as shall meet the requirements of the case.

REVENUE AND TAXATION.

The highest prerogative of government, and one of the most difficult to deal with, is that of taxation. In his inaugural address in 1871, Governor Booth aptly said: "No scheme of taxation has ever been devised which was absolutely just; perhaps none can be." This condition must be accepted, but the nearest approach to equality of taxation that experience can suggest must be our aim.

The revenue laws of the State have been in great part abrogated, and much legislation on this subject is rendered necessary by the new Constitution. The taxation of mortgages, which is one of the new features to be dealt with, will not produce any additional revenue, and will only operate—for good or evil—between borrower and lender. It is required that the amount of the mortgage be deducted from the realty on which it is a lien, and the proceeding renders cumbersome and complicated the duties of both Assessor and Collector.

It is, also, required that all real and personal property, including credits, franchises, bonds, and stocks, shall be taxed, and laws must be passed for the carrying out of this requirement. Not, however, in such manner as to result in double taxation, to which I am most emphatically and unalterably opposed. Debts due to A should be made an offset to a like amount of debts A might be owing to B, and

the assessments made on the balance only. The stock of corporations is required to be taxed. If an attempt is made to tax the real and personal property, franchises, etc., of private persons and corporations, and another taxation of the stock and individual bonds, it would be double taxation, and, as such, oppressive and unjust. To prevent this, and, at the same time, to insure that all the property of any firm or corporation having a capital stock shall be properly taxed, would it not be the plan of wisdom to secure the assessment of all stock at its market value to the company issuing it, after deducting the value of all assessments on the real and personal property of such company as may have been otherwise made?

By this means many millions of dollars may be added to the taxable wealth of the State. The tax being paid by the company, the distribution of the assessment among the stockholders would be equitable, while to attempt to assess the stock to individual holders would prove to be practically impossible, and result in much of it escaping taxation.

Under the present laws improvements constructed on real estate, which is itself exempt from taxation, are not assessable. It seems only just that the Code should be so amended that the improvements alone may be made liable for the amount of the tax.

The new Constitution makes provision for the assessment and collection of income taxes in such cases and amounts, and in such manner as shall be prescribed by law; and while I am not prepared to recommend immediate legislation upon the subject, I am persuaded that a tax upon personal incomes, exceeding say five thousand dollars, properly and impartially executed, would be of most essential service in imposing the burden of taxation upon those most able to bear it, and compel them to aid in supporting the government which makes possible the acquisition of wealth, and protects its possession, thus relieving the limited means of the less fortunate and the small property of widows and orphans from unnecessary impositions. But for the constitutional inhibition against exemption of any property from taxation, I should have been happy to recommend a moderate exemption from taxation of the property of these certain classes of persons; but since that is impracticable, their burdens may be lightened by a just and searching income tax.

NATIONAL GUARD.

Domestic tranquillity and the obligations of the State to the Federal Government alike require that the National Guard should be encouraged and maintained in a state of efficiency, by such proper appropriations as will enable the citizen-soldier to feel that his service and preparation for possible exigencies, which sooner or later may arise in State or national affairs, are appreciated and rewarded. While standing armies have been well designated as a perpetual menace to free institutions, the people should be so sufficiently trained to the use of arms as to make possible the defense of the government in any condition of affairs. The Congress of the United States has this subject now under consideration, and it is not unlikely that liberal appropriations may be made for distribution to the States of funds for the creation and support of the National Guard. In the meantime, I hope the State of California will do its whole duty, so

far as may be consistent with principles of economy, by the National Guard of California.

CHINESE IMMIGRATION.

At the last election, in accordance with the Statute providing therefor, a vote of the people of this State was taken upon the question of Chinese immigration—"for" and "against" the policy of permitting it to continue unrestricted, as at present. Out of a total vote of one hundred and sixty-one thousand four hundred and five only eight hundred and eighty-three votes were "for" such immigration. The ballot was secret—there was no extraordinary excitement on the subject; the result should be accepted as a fair indication of the real opinion of our people on this important question. It ought to be accepted everywhere as conclusive evidence that there is practically no difference of opinion among the people of this State relative to the policy of prohibiting the further increase of the Chinese element of our population. The question has ceased to be a political issue with us. Men of all parties are in perfect accord that immigrants from China are a curse to this country, and that some adequate restriction upon their coming ought to be imposed without delay.

It is seldom that the voters or citizens of an American community so generally agree upon a question of such importance as in this instance. The result cannot be fairly attributed to ignorance or prejudice; fully two thirds of the electors of this State are natives of the United States, and a majority of them are from the Northern and Western States of the Union. They are not affected by race prejudice. By education and association they have been well grounded in the principles of our free institutions, and fully appreciate the sacredness of individual liberty. In proposing to restrict immigration from China, they are not disregarding American precedents, nor running counter to the spirit of our republican government. They remember that this country was discovered, and has been developed, by people accustomed to the beneficent principles of the civil and the common law; that our civilization founded by such people is entirely different from, as it is much younger than, that which prevails in China, and which seems to hold those born under its influence with a power that cannot be broken.

An experience of thirty years has convinced them that immigrants from China do not and cannot assimilate with our people. They come hither without families, with no accurate ideas of free government or of Christian civilization; they retain their native dialects, their national prejudices, and even their race costumes. They take no interest in our political affairs, and manifest no desire to be identified permanently with the country, as do immigrants from other parts of the world. They are handicapped by labor contracts which reduce them to a condition worse than slavery, for the servitude cannot be abolished. Their contracts cannot be annulled by our laws, because they are founded upon the laws, customs, and religious prejudices of China. The result is to renew in another form the "irrepressible" conflict between free and servile labor, which has already cost us one civil war. Hence the people of California say: Here is a new problem in American politics.

Our republican government has extended its jurisdiction across the continent, and stands face to face with the oldest civilization

known to history. It confronts the most populous nation in the world—a country so populous that numbers equal to the entire population of the Union could be spared and their absence scarcely noticed. In all the Pacific States and Territories the population is less than one million five hundred thousand—utterly insignificant when compared to the four hundred millions in China. It costs much less for the immigrant from that country to reach this State than it does for the immigrant from Europe, or even from the older States of the Union. Already nearly one third of the men among us who make their living by their daily toil are Chinamen—Chinamen without families to support, while most of the white laborers have wives and children to provide for. In this country the family is the unit of society. It is the family that makes the home, and the homes of our people are the citadels of our liberty. It is there that respect for law and the love of freedom are fostered until they become so much a part of the nature of the child, that when he reaches manhood he is a useful portion of the political fabric. The Chinese know nothing of this American home culture, and we believe they are incapable of comprehending it. Hence they never can become American citizens in the true sense of the word. Bound in servitude, they differ radically from the class of immigrants for whom our ancestors entertained so friendly a feeling, and whom we have always received with hearty welcome. A new evil arises, for which we must provide a new remedy: that remedy, we believe, is to restrict the immigration of this class of people; and it is for the Federal Government to apply it. The expression of opinion, through the vote lately taken, was intended for the purpose of influencing such action, and it is to be hoped that it may have that effect.

While we must look to the General Government for the complete redress of this evil, the people have attempted, in the new Constitution, to find some relief through the action of the State Government, by directing certain measures to be applied. The attention of the Legislature is therefore respectfully invited to this subject, with the assurance that whatever can be properly and legally done in this behalf by the State shall have my hearty co-operation. Nothing should be done in anger, nor in a spirit of race prejudice, but everything with the fairness and dignity becoming a sovereign State of of the American Union. Undoubtedly the time is rapidly approaching when the importance of this question will be recognized by the people of the United States, and then the public opinion of the nation will find expression in wise remedial measures. Surely the National Republican Party, which has always been the champion of free labor, which had its origin in the struggle against slavery, and has heretofore so jealously guarded all the interests of the people, cannot long remain indifferent to this question, nor fail to recognize the necessity of speedily erecting a barrier against this new danger, which threatens the very existence of our civilization.

LAND MONOPOLY.

One great source of our success and prosperity as a nation is that, under a wise system, the public lands have been disposed of in small tracts to actual settlers. Attaching men to the soil by ownership creates an independent and intelligent population. While there are large areas of dry and desert lands that cannot be cultivated

without large expenditures for costly works of irrigation, and large areas of swamp lands unavailable for agriculture until vast sums are expended in their reclamation, yet, wherever by legislation men have been enabled to monopolize and reduce to private ownership large tracts of farming land for purposes of speculation, it has been in opposition to the wise policy of the founders of the Republic, who sought to give every man wishing to cultivate the soil as much land as would support him and his family, and no more.

In the acquisition of California from Mexico we inherited the evils of a different system. Vast tracts, measured not by acres but by leagues, of the best land, had been granted to private individuals and secured to them by treaty. However much the public prosperity would be promoted by division and sale of these large tracts to actual settlers, I know of no mode by which they can be divided and sold without the consent of the owners.

The State could not exercise her right of eminent domain, and condemn them, for it would be an appropriation of private lands for private purposes; something unknown under our system of government. This evil must be left to time for its eradication. We can have no law of primogeniture and entail; therefore, the evil will not be perpetual. The fluctuation of business enterprises, the certainties of taxation, and the laws of inheritance, will in a few years divide and subdivide these great possessions.

The new Constitution requires that cultivated and uncultivated land of the same quality and similarly situated shall be assessed at the same value. This, with equal taxation prevailing to such an extent that the owner of his leagues of land shall be assessed the same value per acre as the owner of one hundred acres, providing the land is of equal quality, and the few will soon realize the fact that it is not profitable to monopolize the lands of the country. As to the large bodies of public lands within our State still remaining the property of the United States and of the State, that can be cultivated without large expenditures for irrigation and reclamation, I am in favor of such disposition of them only as will provide for their conversion into homes of not exceeding one hundred and sixty acres for actual residents thereon.

But while I consider the policy of taxing uncultivated lands equally with cultivated lands of the same quality to be not only a step in the right direction, but one of the most important reforms in the new Constitution, yet the carrying out of this important trust will devolve upon the Assessors of the different counties and the State Board of Equalization; and if they faithfully perform the duties assigned them, there is no doubt in my mind that the immense tracts of uncultivated lands, now held for speculative purposes, will soon be a matter of history.

It is estimated by the United States Surveyor-General that there is yet in this State about forty million acres of public lands unsurveyed. Our Senators and members of Congress should be requested to urge Congress to make the necessary appropriation to have these lands surveyed, and conveyed to actual settlers only, as it can but conduce to the encouragement of immigration to this State of intelligent, thrifty, and sturdy farmers from other States and countries, to come and settle in a State which possesses such unbounded resources. I shall be pleased to give my hearty co-operation and concurrence to any legislation which favors a policy of conveying our public lands

to actual settlers only, and the discouraging of holding large landed estates.

HARBOR COMMISSIONERS.

The Board of State Harbor Commissioners reported to the late Legislature a bill which provided for a new water-front for the City of San Francisco, and recommended that the lands reclaimed by their proposed plan, if adopted, should be sold.

The Legislature confirmed their suggestions, but wisely declined to authorize the sale of the reclaimed lands. The question now arises, what shall be done with them; shall they be sold, or held as the property of the State.

The Port of San Francisco belongs to, and is of most vital importance to, the State of California; and her citizens are her agents in the domestic and foreign commerce of the State. The State has reserved ownership of the lands on the city front, and controls and directs their use for commercial purposes. Every facility that can be afforded to cheapen the cost of carrying on the exchange of products of the State for those of other countries needed to supply her wants, is of direct pecuniary advantage to every one of her citizens, however remote he may reside from this, her commercial seaport. A wise statesmanship will foresee and provide for her future commercial requirements, and make such provisions in advance as will create new sources of prosperity, or hasten and secure them to herself. Necessarily the surplus products of our State find their money value measured by prices fixed in foreign ports and under foreign competition; hence every dollar that can be saved in the cost of production and transportation (in facilities for handling, storage, wharf, and other port charges) inures to the benefit of the State and its producers, and will go far to help them meet the competition in foreign markets. Every convenience that can be afforded to get our products into the ships, and also to the ships themselves (which are to carry them away or bring back their returns) is a profit which goes directly into the pockets of the producers.

So, also, if we furnish better and cheaper facilities to the trade of our neighboring nations in the Pacific, we shall induce the trade of these countries to pass through our port, to the direct and indirect advantage of our people. As commerce has created these new lands on the water-front they should not be sold by the State to individuals, but be reserved and sacredly appropriated to commercial uses forever.

These lands are not needed for such purpose to any great extent, but as our State and cities grow, the purposes for which different portions of them will be most useful will develop gradually, and a continuance of the wise policy which has reserved them will assign to each portion its proper share in serving the great commercial needs of the metropolis of the Pacific Coast.

NATIONAL POLITICS.

It may be deemed that the affairs of our own State, at this time, are of sufficient importance to engage the full time allotted to this occasion, without any allusion to national affairs. But I cannot forbear to notice the fact that in some of the States violence has been resorted to, and by threats thousands of voters have been prevented

from exercising the constitutional right of suffrage; and more recently, in another State, a mere informality in the election returns, or a clerical error of a town meeting clerk, has been made the pretext to thwart the will of the people and annul their verdict.

A free, uncorrupted ballot is the great bulwark of constitutional liberty, and whenever it becomes apparent that in any State of this Union a result has been reached by violence or fraud, different from that which would have been attained if a fair election had been held, republican government is little more than a delusion and a farce; and I trust that the State of California will be ever ready to use all lawful power so to shape the administration of the National Government, that every citizen entitled to vote shall exercise that right securely under the protection of just and equal laws, and that the result of his vote shall be faithfully recorded and honestly returned as the expressed will of the people.

EDUCATION.

The public system of education will demand at your hands much earnest and careful consideration. The framers of the Constitution of our State declare a general diffusion of knowledge and intelligence to be essential to the preservation of the rights and liberties of the people. Whatever power governs the schools shapes the intelligence of the generation. The destinies of a republic rests upon an intelligent suffrage, and the intelligence of the suffrage depends mainly upon the public school system. The changes in the system made necessary by the new Constitution presents an opportunity of a general review of the existing system, and such wise reconstruction and improvement as experience may have suggested or patient and earnest consideration may develop. A republican government will always be a perfect reflection to the true character of its people, and if we would attain that "righteousness which exalteth a nation," and avoid that "sin which is a reproach to any people," we must become, in its best and truest sense, an educated people.

Liberty will not decay so long as government is controlled and directed by virtue and intelligence, and in a State like ours, where the people are the source of governmental power, general education is the only means by which we may hope to transmit the free institutions under which we live in full vigor to succeeding generations. To neglect or abandon our system of public education, is a surrender to the ignorance and vice which usurp the reins of government when virtue and general intelligence are weakened or decay. Educate our people, and the liberties we enjoy will remain unshaken by the assaults of insidious usurpations and undiminished by the flight of time. The State University is the crowning glory of our educational system. The new Constitution wisely provides for its continuation as a public trust. By the terms of that instrument its government is to be perpetually continued in the character prescribed by the Organic Act, passed March twenty-third, eighteen hundred and sixty-eight, and the several Acts amendatory thereof. It is now subject only to such legislative control as will insure compliance with the terms of its endowments. It is further provided that the funds derived from the sale of lands donated to the State by the Government of the United States shall be invested as directed by the Acts of Congress, and the interest accruing shall be devoted to

the maintenance of a College of Agriculture, where such branches of learning as relate to scientific agriculture shall be taught. It will be the high privilege of this Legislature to devise the necessary details of legislation by which the object of the original grant or donation to this State shall be carried into execution, and I am happy to believe that this responsible duty will be esteemed a sacred privilege, and the obligations imposed will be discharged with that conscientiousness a true appreciation of the moral grandeur of the subject inspires.

AID TO ORPHANS.

I commend to your generous sympathies the claims of the homeless children who, beneath the roofs of the many noble institutions philanthropy has builded, find the shelter denied them by the adverse fortunes of life. I most respectfully recommend the continuance of such judicious State aid as will second the efforts of our charitable citizens. Such aid will, in my humble opinion, do much to encourage and promote the spirit of charity among our people by arraying the testimony of the State on the side of Christian philanthropy.

CONCLUSION.

At the threshold of the administrative duties into which by these ceremonies I am being inducted, I am conscious of a most earnest desire to discharge them as in the high court of truth, honor and justice. To achieve the distinction of an honorable position in the State may be the goal of self-love and pride; to rise equal to the high prerogative by the conscientious discharge of its duty, is the more worthy aspiration of ambition. For the brief term I shall enjoy the honors, and bear the responsibilities of this exalted office, I trust that my every thought shall be directed to the welfare of the State, and my every effort devoted to the promotion of peace and prosperity, the establishment of good government, and the advancement of Christian civilization.

BIENNIAL MESSAGE

OF

GOVERNOR WILLIAM IRWIN

TO THE

LEGISLATURE OF THE STATE OF CALIFORNIA

TWENTY-THIRD SESSION, 1880.

BIENNIAL MESSAGE

OF

GOVERNOR WILLIAM IRWIN.

To the Senate and Assembly of the State of California:

The Constitution of the State makes it the duty of the Governor "to communicate by message to the Legislature, at every session, the condition of the State and recommend such matters as he shall deem expedient."

Without the light of custom, we might be in doubt, in a juncture like the present, whether the duty imposed, in the above provision of the Constitution, rests on the out-going, or on the incoming Governor. But whatever the decision of that question might be, if it were a new or an open one, custom in this State seems to have decided that the Constitution, in that section, addresses itself to the outgoing Governor. It is now the settled common law of the State, that it is the retiring Governor, who must communicate to the Legislature, which meets just as he is on the point of retiring, the condition of the State, and make such recommendations as he may deem the public good to require.

When the last Legislature met, there was wide-spread discontent among the people—the result of a general stagnation in business, and the inability of laborers to obtain employment. Since then the industries and business interests of the State have materially improved, and, with this improvement, there has come also a corresponding improvement in the social, moral, and political tone of the people. It is thus suggested how close the relation is between material prosperity and moral, social, and political order. Hunger in the human stomach is a pent-up force, which may burst forth and shatter to atoms all moral, social, and political systems. Unquestionably that is the wisest statesmanship which does most to keep the wolf from the door of the poor.

I know of no other cause that will contribute so much to secure the peace and order of society, the observance of law, and fidelity to all obligation—moral, social, and political—as general prosperity among all classes of the people.

With a favorable season—and the prospect for one was never better than now—the farmers will reap abundant harvests, the miners will take from the hills more than the usual amount of gold, and laborers will have constant and remunerative employment. All other industries and branches of business will share in the general prosperity:

and we may confidently predict, as one of the consequences, an era of peace, contentment, and happiness.

The most important event in the history of the State, since the adjournment of the last Legislature, has been the adoption of the new Constitution. Prior to its adoption there existed much diversity of opinion as to the policy of adopting it; and its opponents resisted its adoption with all the means at their command. There is no reason to doubt the sincerity of their conviction that many of its provisions were not adapted to promote the prosperity and welfare of the State. No doubt, the friends of the new instrument were equally sincere in their belief that it was not only a great improvement on the old Constitution, but that, under its guidance and protection, the State would enter on a new era of prosperity and happiness.

It is not my purpose now, however, to pass any opinion, as to whether the friends or the enemies of the instrument were right in their opinions as to what the effects of its adoption would be, or whether both were partly right and partly wrong. But I desire to say, that so soon as the new Constitution was adopted, it was removed from the forum of discussion, as to the wisdom or policy of its provisions, and became a law, to be observed and implicity obeyed by all citizens.

And it will be your duty as legislators, in pursuance of your official oaths to support the Constitution, to pass all proper and necessary laws to give effect to its provisions. Acting under the obligations of your oaths, you can not consider the question, whether the execution of a plain mandate of the Constitution will be promotive of the public good or otherwise. The fundamental law of the State, as all other laws, should be strictly executed and obeyed. This is absolutely necessary to preserve, in the public mind, the proper respect for law. If there be laws, constitutional or statutory, which are oppressive, or not beneficial in their operation, the proper remedy is not to disobey or disregard them, but to seek their repeal. And no other method is so effectual to secure the repeal of an unwise or oppressive law, as its strict enforcement. Let the provisions of the new Constitution be fairly and honestly executed, and if any of them are found to operate injuriously or oppressively, let them be amended or repealed.

FINANCES OF THE STATE GOVERNMENT—CONTROLLER'S AND TREASURER'S REPORTS—FUNDED STATE DEBT.

The total funded debt of the State, on June 30th, 1879, was $3,403,000. Of this sum $5,000 consists of the State bonds of 1857, and $1,500 of the State bonds of 1860. Notice was given that all bonds issued at these dates would be paid on presentation, and the interest on them was stopped on and after July 31st, 1875. The interest-bearing funded debt of the State, on the 30th of June, 1879, was $3,396,500.

In addition to this, however, the State, in pursuance of an Act of the Legislature, approved April 4th, 1874, pays the interest on $1,500,000 of Central Pacific Railroad bonds. These bonds will mature on the 1st day of January, 1885, when the obligation of the State to pay the interest thereon will cease.

The annual interest on the funded debt of the State, now bearing interest, is $209,745; on Central Pacific Railroad bonds on which the

State pays the interest, $105,000. The total annual interest paid by the State is $314,745.

The State Board of Examiners are authorized by law to invest the perpetual school fund, derived from the sale of 16th and 36th sections, the 500,000-acre grant, and other sources, in State bonds; and the Regents of the University also are authorized by law to invest the permanent fund of that institution, derived from the sale of lands granted by the United States, from the grant of the State of the proceeds of the sale of salt marsh and tide lands, and from other sources, in such bonds.

In pursuance of such authority the State Board of Examiners have purchased for the School Fund $1,737,500 of State bonds; the Board of Regents of the University, for the University Fund, $952,500.

The funded debt of the State is held as follows:

In private hands	$713,000 00
In trust by State Treasurer for School Fund	1,737,500 00
In trust by State Treasurer for University Fund	952,500 00

The interest paid on State bonds is distributed as follows:

For the support of common schools	$107,760 00
For the support of the University	58,500 00
For private holders of bonds	43,485 00
Interest on Central Pacific Railroad bonds is paid to private holders	105,000 00
Total	$314,745 00

Thus it is seen that nearly eighty per cent. of the interest, which the State pays on her own bonds, goes to the support of the common schools and the University.

At the expiration of five years, from this date, the State will be released from the payment of interest on bonds of the Central Pacific Railroad Company, as at that time the bonds will have matured, and must be provided for by the company.

The Act authorizing the issue of these bonds by the railroad company provides, that in consideration of the State paying the interest on $1,500,000 of them for a period of twenty years, "the company shall, at all times, when required, convey over their road—to aid in the construction of which the bonds were to be issued—all public messengers, convicts going to the State Prison, lunatics going to the State Insane Asylum, material for the construction of the State Capitol building, articles intended for public exhibition at the fairs of the State Agricultural Society, and, in case of war, invasion, or insurrection, as well as at all other times, also transport and convey over the said railroad all troops and munitions of war, belonging to the State of California, free of charge, and without any other compensation than as herein provided."

What the value of the services rendered by the company in "transporting material for the construction of the State Capitol," was, I have no means of knowing. The services, however, which have been rendered in carrying public messengers, convicts to the State Prison, insane persons to the lunatic asylums, articles for exhibition at the State Agricultural Fair, and troops and munitions of war, have been insignificant and unimportant. The obligation of the State to pay interest on the company's bonds was assumed to aid in the construction of that portion of the company's road, lying between

the City of Sacramento and the eastern boundary line of the State, and the State acquired the right of free transportation, for the purposes specified only, over that portion of the road. It is manifest that the State can have but little occasion to use the rights which it acquired, in consideration for the payment of $105,000 of interest a year on the company's bonds. The value of the yearly services which the company now renders, in consideration of the payment by the State of that sum annually, cannot exceed a few hundred dollars, if on the average it reaches that amount.

Another condition of the grant was, that the company should construct and equip not less than twenty miles each year of the road, in aid of which the grant was made, till it should be completed. I presume this condition was complied with; and if, in consequence of receiving such aid, the company was enabled to join its road with the Union Pacific at a date materially earlier than it otherwise could have done, the State, no doubt, received some consideration for its grant, in its more speedy realization of the advantages which resulted from communication by rail with the eastern side of the continent.

It has already been stated that the present funded debt of the State is $3,403,000; that that portion of it which is interest-bearing is $3,396,500.

From the Controller's report it appears that there will be in the Interest and Sinking Fund, after the payment of the interest falling due on the 1st of January, 1880, applicable to the redemption of bonds, the sum of $96,386 47.

There is no provision of law directing or authorizing the purchase of State bonds with this sum. The Controller recommends the passage of an Act authorizing the State Treasurer to exhaust it in the redemption of bonds. That cannot be other than a bad financial arrangement which collects large sums of money in the treasury for some specific purpose, but provides no way in which such money can be used to accomplish such purpose. I, therefore, join with the Controller in recommending legislation by which the money now in the Interest and Sinking Fund, or which may hereafter come into it, not required for the payment of interest, may be used in redeeming State bonds.

The sum now in the Interest and Sinking Fund, not required to pay interest, would, if applied to the redemption of bonds in private hands, reduce the aggregate of bonds thus held to about $617,000; and the annual interest, which the State has to pay on her bonds in private hands, would be reduced to about $37,000.

It should be a source of just pride, as well as of profound satisfaction, to the citizens of this State that the State debt, less the amount in the Interest and Sinking Fund applicable to its extinction, is but $3,306,613 53; and the interest which the State pays on her indebtedness, except $43,485—which, as soon as the money in the Interest and Sinking Fund shall be applied to the reduction of the debt, will be reduced to about $37,000—goes to support the common schools and the University.

The comparative freedom from debt, which the State enjoys to-day, is due in no small measure to the wisdom and patriotism of the framers of the Constitution. They provided, in that instrument, that no debt in excess of $300,000, except in certain specified contingencies, should be created unless by a direct vote of the people. The

statesmen who framed the Constitution no doubt believed they had erected an effectual barrier against the creation of debt by the Legislature; and there is little doubt that the constitutional inhibition against the creation of debt, beyond $300,000, has operated to check, though it did not wholly suppress, the tendency to run into debt. It is a part of the history of the State, however, that liabilities, in excess of $300,000, were created, notwithstanding the constitutional inhibition. These liabilities, though wholly without legal validity, were subsequently validated by the vote of the people.

AMENDMENT TO THE CONSTITUTION SUGGESTED.

But my purpose now is not to write a history of what has been done in the matter of creating debt in violation of the Constitution, but to point out that the original Constitution, framed at Monterey, left a way open by which debt—virtual debt—to any amount might be created, without violating any of its provisions.

By an Act, approved April 4th, 1864, the State assumed the payment of $2,100,000, the interest for twenty years on $1,500,000 of Central Pacific Railroad bonds. This Act was resisted in the Courts, on the ground that it created a debt of more than $300,000, without first having submitted the question of its creation to a vote of the people.

The Court held, that though the State entered into an obligation to pay semi-annually for twenty years, the sum of $52,500 to the holders of Central Pacific Railroad bonds—or in the aggregate $2,100,000—this obligation did not create a debt, in the sense in which that term is used in the Constitution, where it forbids the creation of a debt of over $300,000.

The process of reasoning by which the Court reached this conclusion was this: Under the Constitution, the Legislature has an unlimited power to tax; and an unlimited power to make appropriations. In the exercise of these powers, the Legislature has levied an annual tax, for a period of twenty years, sufficient to produce the sums each year which the State has agreed to pay; and has appropriated the sums, thus to be raised, for the payment of the obligations of the State, as they shall semi-annually mature. Thus the moment the semi-annual interest on the bonds becomes due—the moment it matures into a claim against the State—the money is in the treasury, and appropriated, to pay the claim. Reasoning thus, the Court held that the Legislature might bind the State to pay any amount, no matter how great, in the future; provided that it, contemporaneously with the creation of such obligation, levied the taxes necessary to produce the required sums, and appropriated such sums, to pay the liability, when it should accrue. Practically, therefore, the Legislature was without restriction, on its power to create State debt; or, which was virtually the same, the power to bind the State to the payment of money in the future.

What was the weak point in the Constitution? And how was the remedy to be applied?

It will be observed that this conclusion was a corollory from two recognized powers of the Legislature, under the Constitution as it then existed. First, the power of the Legislature to levy taxes, without limitation as to the amount, or as to the duration of the time through which the levy might extend, provided only that the object for which the levy was made was not prohibited by the Constitution;

second, the power of the Legislature to make appropriations, without limitation as to the amount, or as to the period through which they might extend.

The weak point in the Constitution manifestly was in the want of a proper restriction on the power of the Legislature to levy taxes, or to make appropriations, or on both these powers. The remedy, which suggested itself, was the imposition of a restriction on the power of the Legislature to make appropriations.

At the session of the Legislature, next succeeding the decision of the Supreme Court sustaining the Act, which bound the State to pay $2,100,000 of interest on Central Pacific Railroad bonds, the following amendment to the Constitution was proposed:

The Legislature shall have no power to make an appropriation for any purpose whatever, for a longer period than two years.

In due time this proposed amendment was adopted. It became Section 22, Article 1 of the old Constitution. It was intended to prevent the Legislature from involving the State in debt, through the exercise of an unrestricted power of taxation and appropriation. It is believed it would have proved effective for the purpose in any emergency.

The new Constitution contains the same provisions on the subject of the creation of State debt, found in the old, as originally made, and no others. The provision which was incorporated into the old, after the decision of the Supreme Court affirming the doctrine that the Legislature, through its power to levy taxes and appropriate money, might bind the State to the payment of unlimited sums in the future, to restrict the power of the Legislature to make appropriations for a longer period than two years, is omitted from the new. And now, if the doctrine of the Supreme Court of this State in People vs. Pacheco (27 Cal.) be good law, there is nothing in the Constitution to prevent the Legislature, at its present session, from placing the State under valid obligations to pay in the future, sums aggregating $5,000,000, $10,000,000, or even $50,000,000.

I do not wish to intimate that there will be any disposition on the part of the Legislature to make such a use of its power. But it is not too much to say, that the people will not feel secure while they know the Legislature possesses the power to involve the State in unlimited financial obligations. When the people adopted the old Constitution they believed it would restrict the Legislature in the creation of debt, except in certain specified contingencies, to $300,000; in adopting the new, they believed it to contain a like restriction on the Legislature.

That the State may in fact enjoy the protection from debt, which Article 8 of the old Constitution was intended to give, but did not, and which Article 16 of the new is intended to give, but perhaps will not, steps should be taken to incorporate into the present Constitution a provision similar to the one incorporated into the old Constitution, after the decision of the Supreme Court, sustaining the constitutionality of the Act which bound the State to pay in semi-annual installments of $52,500 each, the sum of $2,100,000, interest on Central Pacific Railroad bonds.

APPROPRIATIONS AND TAXES.

Two of the necessary functions of the Legislature are the levying of the taxes, and making the appropriations, required for the support of the government.

Under the Constitution no money can be drawn from the treasury, except in pursuance of appropriations made by law. No matter how much money may be in the treasury, not a dollar of it can be drawn out till it shall have been appropriated, by Act of the Legislature, for some specified purpose.

Under the system of biennial Legislatures which has obtained since 1863-64, each Legislature has made appropriations for the two succeeding fiscal years, commencing on the 1st of July subsequent to the meeting of the Legislature. The Legislature which met on the first Monday of December, 1877, made appropriations for the two fiscal years terminating on the 30th of June, 1880.

Had there been no change in the Constitution of the State, no other appropriations would have been required for the present fiscal year, except in the case of deficiencies, or in cases where, by new legislation, new appropriations might have become necessary. The adoption of a new fundamental law, however, which abolishes some of the offices which existed under the old and establishes others in their stead, and creates still others, with powers and functions unlike any previously existing, will make a supplemental appropriation bill, for the last half of the current fiscal year, absolutely necessary.

As, for example: The new Constitution creates the office of Superior Judge and the office of member of the State Board of Equalization—offices which did not exist under the old Constitution. The Superior Judges will be paid half, and the members of the State Board of Equalization in whole, out of the State treasury. The Judges of the Supreme Court are increased from five to seven, and the Railroad Commissioners from one to three. Before these officers can draw their salaries from the treasury the proper appropriations must be made.

Each Legislature, in addition to the regular appropriations, and such special appropriations as the legislation of the session may have made necessary, must make, also, deficiency appropriations in all cases in which the regular appropriations made by the preceding Legislature have proved inadequate. As, for example, if the appropriation for the support of the State Prison, or for the support of the Insane Asylums, made by one Legislature for the next two fiscal years, should be insufficient for the purpose, it would be the duty of the succeeding Legislature to make an appropriation to supply the deficiency.

In the matter of appropriations, it will be the duty of the Legislature:

First—To make such appropriations for the last half of the present fiscal year, in addition to the regular appropriations already made, as are made necessary by the new offices created by the new Constitution:

Second—To make such deficiency appropriations as are made necessary by the insufficiency of the regular or special appropriations of the last Legislature.

Third—To make the regular appropriations for the fiscal year,

commencing July 1st, 1880. This Legislature will not be required to make appropriations for two fiscal years, as the next Legislature will meet on the first Monday of January, 1881.

Fourth—To make such special appropriations as the laws which shall be enacted during the session shall make necessary.

TAXES.

Each Legislature must provide, also, for a sufficient levy of taxes to produce the sums it appropriates. The Legislature of 1875-76 levied taxes to meet the appropriations it made, to wit: the regular appropriations for the two fiscal years, commencing July 1st, 1876, and ending June 30th, 1878; the special appropriations made necessary by the laws enacted during the session, and appropriations necessary to supply the deficiencies in the appropriations made by the Legislature of 1873-74 for the two fiscal years ending June 30th, 1876. And the Legislature of 1877-78 levied taxes to meet the appropriations it made, to wit: the regular appropriations for the two fiscal years ending June 30th, 1880; the special appropriations made necessary by the laws enacted during the session, and such deficiency appropriations, as were required to supply the deficiencies in the appropriations for the two fiscal years ending June 30th, 1878.

The Legislature of 1875-76 directed taxes to be levied as follows:

FOR THE 28TH FISCAL YEAR.

For the General Fund	$2,220,000 00
For the School Fund	1,201,000 00
For the Interest and Sinking Fund	315,000 00
Total	$3,736,000 00

FOR THE 29TH FISCAL YEAR.

For the General Fund	$1,608,000 00
For the School Fund	1,300,000 00
For the Interest and Sinking Fund	315,000 00
Total	$3,223,000 00

The Legislature of 1877-78 directed taxes to be levied as follows:

FOR THE 30TH FISCAL YEAR.

For the General Fund	$1,320,000 00
For the School Fund	1,200,000 00
For the Interest and Sinking Fund	315,000 00
Total	$2,835,000 00

FOR THE 31ST FISCAL YEAR.

For the General Fund	$1,450,000 00
For the School Fund	1,250,000 00
For the Interest and Sinking Fund	315,000 00
Total	$3,015,000 00

It will be observed that the taxes which the Legislature of 1875-76 ordered to be levied exceeded those ordered levied by the Legislature of 1877-78 by $1,109,000, though there are included in the amount to be raised by the latter, the sum of $150,000 appropriated to defray the expenses of the Constitutional Convention, the sum of $120,000 to aid in the construction of the Folsom Branch Prison, and the sum

of $100,000 to defray the expenses of the State Engineering Department—in all $370,000. All these expenditures were for purposes other than the regular and ordinary operations of the State government. Had these appropriations, for these extra and outside purposes, not been made, the taxes which the last Legislature would have had to order levied would have been nearly $1,500,000 less than those which the previous Legislature had found it necessary to order levied.

Why was this? Why did the Legislature of 1875-76 find it necessary to provide for the raising of so much larger sums of money than the Legislature of 1877-78? Was it because it, recklessly and prodigally, made unnecessary appropriations? The large appropriations made by the Legislature of 1875-76 were not due to any such cause. That Legislature was compelled to make deficiency appropriations and special appropriations, to pay equitable claims which had accrued during the previous administration, and special appropriations for the construction of public buildings which had been destroyed by fire, amounting in the aggregate to $1,269,985 70. The Legislature could not refuse to make these appropriations, nor to provide, by taxation, the necessary sums to meet them, without both sacrificing the public interests and bringing discredit on the State.

RATES OF TAXATION.

The rate of taxation for State purposes was:

For the 28th fiscal year, on each $100 valuation	73.5 cents.
For the 29th fiscal year, on each $100 valuation	63 cents.
For the 30th fiscal year, on each $100 valuation	55 cents.
For the 31st fiscal year, on each $100 valuation	62.5 cents.

The increase in the rate of taxation the present year over the rate of last year is due to two causes: First, the larger amount to be raised; the amount to be raised this year exceeds that of last year $180,000. This is due to two facts: First, the meeting of the Legislature this year, and the increase in the number of school children; the law requiring that the sum raised by taxation for the support of schools shall be in proportion to the number of school children; second, the smaller amount of property to be taxed. The assessment roll this year is $36,960,882 less than it was last. To produce a given sum, the rate of taxation must vary inversely as the assessment roll.

APPROPRIATIONS FOR THE NEXT FISCAL YEAR.

The law makes it the duty of the Controller to present with his biennial report an estimate of the appropriations which will be required for the next two fiscal years. In pursuance of this requirement the Controller has presented an estimate of the regular appropriations which will be required for the two fiscal years ending June 30th, 1882. These estimates aggregate for the two years $6,044,724. And from such estimates are omitted all estimates of appropriations which will be required for the Board of Railroad Commissioners, including the salaries of the Commissioners, and for the Board of Equalization, including the salaries of the members. In the estimate is included the mileage and per diem of the members and the other expenses of one session of the Legislature. These aggregate $95,000.

As, however, another Legislature will meet in January, 1881, the

present one will, I presume, not regard it as incumbent on it to make appropriations for more than one fiscal year, to wit: the fiscal year that will end on the 30th of June, 1881. Such fiscal year will embrace the appropriations for the session of the Legislature, and half of all the other appropriations, included in the Controller's estimate.

The present Legislature must, therefore, on the basis of the Controller's estimates, make appropriations as follows:

For the Legislature	$95,000
For other purposes	2,974,862
Total	$3,069,862

To this must be added the appropriations that will be required to defray the expenses of the Board of Railroad Commissioners, and the Board of Equalization, including salaries.

The Controller, in making up his estimate, takes cognizance only of such appropriations as are required by existing laws. In other words, his estimate embraces only such appropriations as may properly be termed the regular appropriations. It includes the appropriations for the salaries of public officers, for the support of public institutions, for the maintenance of the common schools, and for such other purposes as are provided for by the laws already on the statute book.

Some of these appropriations are definite in their amount, while others vary according to circumstances.

Salaries are fixed by law; and the sums necessary to pay them are, accordingly, definite in amount. The sums necessary, however, to support the Insane Asylums, or the State Prisons, will depend on the number of inmates, and other varying conditions and circumstances. While, therefore, the Controller can estimate with exactness the appropriation necessary to pay the salaries of public officers, he will be able only to approximate those required for many other purposes. Hence his estimate of the total amount of appropriations, which the Legislature must make, may be either too great or too small. From an examination, however, of his estimates of appropriations, whose amounts are not definitely fixed by law, I am satisfied that they are more likely to be below, than above, what will be required.

But in addition to the regular appropriations, whose probable amount the Controller has estimated, the Legislature will doubtless find it necessary to make some deficiency appropriations, and also some special appropriations. To some special appropriations, which I think should be made, I will hereafter call attention.

And now in closing what I have to say touching the financial condition of the State, and the operations of the State Government in collecting and disbursing the public revenue, I desire to bear my most willing testimony to the very able and faithful manner in which the Controller and Treasurer have discharged the extremely onerous and responsible duties of their respective offices.

REPORT OF THE BOARD OF EQUALIZATION.

The State Board of Equalization, since it has been shorn, by a decision of the Supreme Court, of the powers originally conferred on it, or rather attempted to be conferred on it, has been a Board of Equalization only in name. It has possessed none of the powers

which a Board should have, to entitle it to such a designation. It has had no power to equalize assessments, nor has it attempted to exercise any such power. In fact, its functions have been pretty much limited to answering questions, propounded by County Assessors, Auditors, and Collectors, touching the revenue law; and to levying the taxes for State purposes. The first of these functions is, doubtless, very useful when intelligently and conscientiously exercised; the latter is not merely useful; it is absolutely necessary; it must be exercised by some one—by the Legislature or by some Board commissioned for the purpose.

But these are not the functions which should especially characterize a State Board of Equalization, though such Board should possess and exercise them.

A State Board of Equalization must be vested with power not only to advise local revenue officers, with respect to the scope and meaning of the revenue laws, and with respect to their duties, but also with power to compel such officers to discharge their duties. It should be made the duty of such Board to see that the revenue law, in all its branches and departments, and in every locality, is faithfully and impartially executed. And it should be clothed with ample but appropriate powers to enable it to perform this duty. It is only by a faithful and impartial execution of the revenue laws that the great and manifold evils of unequal taxation can be avoided.

The provisions of the Code, prescribing the powers of the State Board of Equalization, were declared unconstitutional, because the Constitution provided that Assessors and Collectors should be elected by the people of the districts in which they were to assess and collect. This provision made the local Assessor the final arbiter of the value of property in his district. It mattered not how completely, as a matter of fact, he might disregard the law in making assessments, nor how far the assessed value of property might be from the actual value, it was beyond the power of the Legislature to provide another tribunal, not elected by the people of the district, either to compel the Assessor to observe the law in making assessments, or to correct the errors or mistakes in his valuations.

And how little regard local Assessors paid to the law, which prescribed how property should be assessed, prior to the establishment of the State Board of Equalization by the Code, is shown by the fact that the first assessment made under the supervision of the Board was over $636,000,000, while the highest assessment, which had ever been made before, was under $269,000,000. That this statement may be properly appreciated, it should be observed: First—that the law prescribed the same rule for the assessment of property before the adoption of the Code that was prescribed by the Code, to wit, the rule of full cash valuations; and second—that the powers which the Code assumed to confer on the State Board of Equalization, not yet having been decided unconstitutional, were freely exercised without question, or, at least, without hindrance.

Assuming that property in 1872, when the assessment roll reached over $636,000,000, was not assessed above its actual cash value—the standard according to which the law required property to be assessed—we can form some opinion as to how far short of observing the law and performing their duty the local Assessors fell in 1871, when the assessment roll was less than $269,000,000. But the small aggregate of the assessment of 1871 was not its worst feature. A comparison

of the assessment rolls of the several counties for 1871 with those for 1872 will show that while in many counties, notably in the poorer mountain counties, property was assessed at from 60 to 80 per cent. of its value, in many of the more prosperous and wealthy counties it was not assessed at more than 33⅓ per cent. of its value, and in one county was assessed at not more than 20 per cent. of its value.

It perhaps may not be a matter of very great importance what rule for the assessment of property may be adopted—whether the rule of full cash valuation, or the rule of 25, or 50, or 75, or some other per cent. of such valuation. It is a matter of the first importance, however, that the rule which shall have been adopted, whatever it may be, shall be faithfully and impartially observed. It is only by such observance of the rule that the evils of unequal taxation can be avoided and the people of every locality be compelled to bear their just share of the public burdens.

The new Constitution establishes a State Board of Equalization. What is more, it does not contain a provision, as did the old, which will prevent the Legislature from conferring on it the powers necessary to secure the assessment of property according to law. It will devolve on the Legislature to pass such laws as will secure, through the supervision and agency of the State Board of Equalization, the impartial assessment of every character of property in every part of the State, according to the rule prescribed by law.

REPORT OF THE ATTORNEY-GENERAL.

The Attorney-General, in his biennial report, gives a brief summary of the transactions of his office during the two fiscal years terminating on the 30th day of June, 1879.

The abstract from his official docket, which he appends to his report, gives a concise and intelligible statement of the various suits to which the State was a party, at any time during the period covered by the report, their history and status at the date of the report.

Remarking on this abstract the Attorney-General says: "It will be seen that the business of this office has considerably increased over former years. I regret to say that the criminal record of our Courts shows an increase of crime rather than a diminution."

When real estate has been sold for unpaid taxes, and the State has become the purchaser, it is necessary under existing provisions of the revenue law, to bring a suit to place the State in possession of such lands, before the State can again sell and give title to them. The prosecution of this suit is necessarily attended with considerable of trouble, delay, and expense. The Attorney-General suggests that in all cases in which the title to real estate has become vested in the State, by reason of the State's purchase of such real estate at tax sales, and such real estate is not held by any actual adverse possession, the bringing of suits to give to the State the possession, is wholly unnecessary. He accordingly advises that the law be so amended that all lands belonging to the State which shall have been acquired by purchase at tax sales, of which there is no actual possession adverse to the State, may be sold, and the State's title conveyed to the purchaser, without having first gone through with the troublesome and expensive, but wholly unnecessary proceeding of a suit to place the State in possession.

The Attorney-General calls attention to the fact that, though the

law provides for vesting in the State the title to real estate subject to escheat, yet it makes no provision for the sale and conveyance of such lands by the State. The law, it is true, makes provision for the State receiving the rents and profits of such lands. But the Attorney-General, holding that to engage in the business of landlord is not one of the purposes for which government is instituted, and, moreover, that the public interests would not be promoted by the State engaging in such business, advises that proper provision be made for the sale and conveyance by the State to private parties, of all real estate, of which she is now or may hereafter become the owner by reason of escheats.

In this recommendation, as well as in the one to allow the State to sell real estate purchased at tax sales without a suit to obtain possession, when there is no actual adverse possession, I most heartily join the Attorney-General.

It is required by constitutional provision that all moneys derived from escheated estates shall be paid into the perpetual school fund. The law requires the proceeds of escheated estates to be kept in a separate fund in the treasury; but there is, I believe, no provision of law requiring or authorizing the transfer of what may be in such fund to the Perpetual School Fund. I would suggest that proper provision be made for the transfer of such sums as may now be in, or may hereafter come into, the "Fund of the Estates of Deceased Persons" to the Perpetual School Fund. Whether these sums be much or little, they should be placed where they will yield something for the support of the common schools.

I desire to express my appreciation of the uniform courtesy of the Attorney-General in all his relations with the Executive office, and of the cheerfulness with which he has given legal advice whenever it has been sought.

REPORT OF THE SECRETARY OF STATE.

The report of the Secretary of State, herewith transmitted, contains a concise, but extremely lucid, statement of the transactions of his office during the last two fiscal years.

The law prescribes the fees he shall charge for various services which he is required to perform, such as filing and recording certified copies of articles of incorporation and issuing certificates thereon, certifying commissions to Notaries Public and Commissioners of Deeds, making copies of laws, and public documents, and records, etc. His report shows that he received for these services and paid into the State treasury a much larger sum than was received and paid into the treasury by his predecessor for like services.

The law makes the Secretary of State the agent of the State to order and receive from the contractors wood, coal, stationery, etc., as they may be required. And it devolves on him to issue to the State officers, members of the Legislature, and whoever else may be entitled to receive them, all articles classed under the head of stationery.

The report shows that the expenditures for stationery, lights, fuel, etc., have been much less during his term than they were during the term of his predecessor. But for details in relation to these matters, as in relation to all others, I beg to refer to the report itself.

The report furnishes ample proof that the office, during the term

of the present incumbent, has been ably, intelligently, and economically administered.

REPORT OF THE SURVEYOR-GENERAL.

For the transactions of the State Land Office, from August 1st, 1877, to August 1st, 1879, I beg to refer you to the report of the Surveyor-General, herewith submitted.

In addition to the transactions of the office, during the period named, the report contains a great amount of interesting and valuable information, touching the number of acres of land in the State; the number of acres of the several classes of land, as agricultural, mineral, swamp, etc.; the number of acres, surveyed and unsurveyed, of the several classes; the number of acres in private grants, surveyed and unsurveyed; and also touching the present condition of the several grants by Congress to the State.

It also contains a valuable compendium of the industrial and other statistics of the several counties, furnished by the County Assessors.

The provisions of the new Constitution, in relation to the disposal of lands belonging to the State, will make necessary a revision of the laws at present in force on that subject. I invite the careful and intelligent consideration of the Legislature to this subject.

It gives me pleasure to have an opportunity to express my very high appreciation of the able, just, and impartial manner in which the office of Surveyor-General has been administered during the past four years.

REPORT OF THE ADJUTANT-GENERAL.

The report of the Adjutant-General gives a detailed account of all matters relating to the organized militia of the State for the two years ending July 31st, 1879. It leaves little room to doubt that there has been a steady advance during that period in the organization, discipline, and efficiency of the National Guard of California.

It is hardly necessary to produce arguments to demonstrate, or to cite examples to illustrate, that it is not only important but absolutely necessary to have an armed force, subject to the command of the proper authority, to aid the civil officers to enforce the laws and preserve the public peace, in cases of emergency. Occasions when it will become necessary to have recourse to the organized militia may not often occur, and it would be a cause of the greatest gratification to all good citizens if they should never occur.

The organized militia should be regarded as an extraordinary or supplemental force, which should never be called on except when the civil administration and the ordinary police shall be manifestly inadequate to the task of protecting life and property, and of preserving the public peace. In an emergency of this kind it is as legitimate and as much the duty of the proper authority to invoke this extraordinary or supplemental force as it is to rely on the civil officers to execute the law, and the ordinary police to protect life and property, when their power is adequate for these purposes.

Wise statesmanship must provide for extraordinary occasions, though such occasions may not often, or may never, occur. If there be a possibility of their occurrence, suitable provision must be made to meet them in the event they do occur. The public authority in all civilized States must maintain a sufficient public force to main-

tain order and preserve the public peace. If no emergency arise when it shall become necessary to invoke the extraordinary force provided and maintained for extraordinary occasions, so much the better. The existence of such force will, no doubt, have a powerful influence in preventing the occasions for its use.

The companies of the National Guard now organized, or authorized to be organized, will, if properly officered and drilled, and distributed, prove a sufficient supplemental force in aid of the civil officers and the ordinary police, to protect life and property and maintain the public peace in any emergency likely to arise. If the Legislature will continue to the National Guard financial support on the basis which was inaugurated at the last session, it will have no excuse for not being effective, nor for not rendering, in any emergency, whatever service could be reasonably demanded or expected of it.

I desire to call the attention of the Legislature, especially, to the recommendations of the Adjutant-General's report. And it is proper now that I should express my appreciation of the devotion of the Adjutant-General to the interests of the National Guard, and my sense of the value of his service in bringing it to a higher state of discipline and efficiency, and in imbuing it with juster views of its true functions as a real and recognized factor in the government of the State.

REPORT OF THE SUPERINTENDENT OF PUBLIC INSTRUCTION.

The report of the Superintendent of Public Instruction shows:

That the number of school census children—children between the ages of 5 years and 17—was:

In 1878	205,475
In 1879	216,404

That the number of census children who attended the public schools at any time during the year was:

In 1878	138,594
In 1879	144,806

That the average attendance was:

In 1878	103,006
In 1879	105,837

That the number of schools was:

In 1878	2,578
In 1879	2,743

That the number of teachers was:

In 1878	3,293
In 1879	3,453

That the total value of school property was:

In 1878	$6,343,369 85
In 1879	6,857,389 00

That the total expenditures for school purposes were:

In 1878	$3,155,815 27
In 1879	3,010,907 13

That the total cost per scholar enrolled during the year was:

In 1878	$17 95
In 1879	17 34

That the total cost per scholar in average attendance was:

In 1878	$26 85
In 1879	25 67

A mere glance at these figures will suffice to show how vast an interest is our common schools! The children of the school age number more than 200,000. Every one of these should not only have the opportunity to receive, but should actually receive, a common school education. Not only the welfare and happiness of the individual demands this, but the peace, security and prosperity of society as well. The education of the children is one of the most important and responsible duties devolving on the State. Not only is the duty a most important and imperative one, but its proper discharge involves the expenditure of vast sums of money. At present, our common schools make a demand for more than $3,000,000 annually. I do not wish to intimate that they are costing more than they ought, or more than we can afford. But it would be pertinent to inquire whether our schools are giving to the children as much education, and as good, as they might; and whether the $3,000,000, and more, which is now expended annually, in the support of common schools, is accomplishing as much, in the way of equipping the children of the State for the battle of life, as it should. To inquire whether our schools are accomplishing with a reasonable degree of success the purposes for which alone schools are maintained, and whether the money expended in their support is expended wisely and judiciously, is not to attack the cause of common school education. While I do not say that less money should be expended in the support of common schools, I do say that the Legislature should provide, so far as it may be in its power, for a judicious and economical expenditure of whatever funds may be devoted to this purpose. The Legislature has been liberal in providing revenue for the support of the common schools; there may be a question, however, whether it has been wise and statesmanlike in devising a system through which this revenue might do the most in promoting education.

The provisions of the new Constitution on the subject of education make it necessary that important changes be made in the school law. I shall express no opinion as to the policy embodied in the new fundamental law touching the common schools. The final test of the wisdom of any measure or policy is the test of experience. The provisions of the new Constitution on the subject of education, as on all other subjects, are about to be submitted to this test.

It will be the duty of the Legislature to enact all necessary and proper laws to carry the mandates of the Constitution into effect. And I respectfully invite the careful and considerate attention of the Legislature to the subject of the changes in the existing school law,

which it will be necessary to make to bring it into harmony with the new Constitution.

I desire to bear testimony to the earnestness and zeal with which the Superintendent of Public Instruction and his Assistant have labored during the past four years to improve the character of the public schools.

REPORT OF SUPERINTENDENT OF STATE PRINTING.

The report of the Superintendent of State Printing covers the period from December 1st, 1877, to July 1st, 1879, his first biennial report having extended over the period from December 1st, 1875, to December 1st, 1877, in accordance with the law at that time.

The report shows:

That the expenditures of the State Printing Office were, from December 1st, 1877, to July 1st, 1878	$45,491 93
For the 30th fiscal year, ending June 30th, 1879	81,654 88
That of the expenditures of the 30th fiscal year there was, for the Constitutional Convention	22,761 87
Printing material purchased	4,568 79
Paper on hand at date of report	9,338 38
Total extraordinary expenditures	36,669 04

The Superintendent institutes a comparison between the cost of the work done at the State Printing Office since it went into operation on December 1st, 1875, to date of report, July 1st, 1879, and what the same work would have cost under the old system, at the rates fixed by law:

Cost of work done at State Printing Office from December 1st, 1875, to January 1st, 1879	$205,133 00
Same work would have cost under the old system	279,202 27

The Superintendent states also that by his advice the office of Copying Clerk was abolished, and bills were sent direct to the State Printing Office. Thus the expense and delay of having bills copied were avoided, the original bills being used by the compositors. The Superintendent was made responsible for the bills, as the Copying Clerks had formerly been. He claims that in this way there was saved to the State during the last two sessions of the Legislature, $13,420, it having cost that amount for the Copying Clerks' offiees during the two preceding sessions.

On his advice the law was so changed at the last session of the Legislature that hereafter bills, immediately on their passage, will be taken to the printer, instead of to the Enrolling Clerk. A printed copy of the bill, struck off on proper paper, will become the "enrolled bill," which will be certified by the proper officers of the Legislature, and signed by the Governor. In this way the expense of enrolling bills by Enrolling Clerks, which is always very great, will be avoided.

This law, however, will impose very considerable additional work on the State Printing Office, during the sessions of the Legislature. It provides that when a bill has been set up, and the "enrolled bill" struck off, as many copies shall be made as will be required for the edition of the statutes. Thus will the demand on the capacity of the Printing Office be much greater than it has been heretofore.

Upon this point, and upon the advantages which will result from the law, the Superintendent remarks: "To carry out the provisions

of the law, it will be necessary to purchase an additional book press at a cost of $4,500, and type to the value of $2,500; which amount does not exceed the sum it would be necessary to pay for the enrollment of bills during one session of the Legislature, by Enrolling Clerks, if this amendment had not been adopted, as shown by the Controller's books in account with previous Legislatures, to say nothing of the convenience and importance of having the statutes printed and distributed to the Legislature while in session, and to the public as soon as enacted, instead of three or four months thereafter, as was necessarily the case under the old law." I fully concur in his statement of the benefits that will result from the execution of the law.

I think the experience of the last four years fully demostrates the wisdom of the change from the old method of having the State printing done to the present one.

The quality of the work done at the State office will not suffer in comparison with similar work done at any other State office in the United States, and bears eloquent testimony to the mechanical skill of the Superintendent and his assistants and the employés.

STATE PRISON.

I beg to call the special attention of the Legislature to the very interesting and able biennial report of the Resident Director of the State Prison. The report gives a very full and detailed account of all matters which transpired at the State Prison, at San Quentin, during the two fiscal years which closed on the 30th of June, 1879.

The report shows:

That the number of prisoners in the Prison was—	
On July 1st, 1877	1,318
On June 30th, 1879	1,564
Increase in two years	246
That the monthly average number of prisoners during the two years was	1,475
That the cost of maintaining prisoners for two years was	$391,980 94
That the daily cost, per capita, was	$36\frac{4}{10}$ cents.
That the total earnings of the Prison, during two years, was	$100,269 56
That the expenditures during two years, other than for maintaining cost, mainly for permanent improvements, was	56,690 78

There is included in maintaining cost all expenditures for feeding, clothing, and bedding the prisoners, furnishing them with medicines and medical attendance, etc., the salaries of officers and guards, and the wages of all employés, and for ordinary repairs.

The maintaining cost, per capita, of prisoners has been less during the last two fiscal years than ever before, as appears from the following table, taken from the Warden's report:

Daily maintaining cost, per capita:

For two years ending June 30th, 1879	36.4 cents.
For two years ending June 30th, 1877	42.7 cents.
For two years ending June 30th, 1875	44 cents.
For two years ending June 30th, 1873	$53\frac{1}{6}$ cents.

This exhibit must, I think, be quite satisfactory, so far as economy in the management of the Prison is concerned; but the statement above, as to the earnings of the prisoners, must be quite the reverse of satisfactory.

It will be observed that, while the whole cost of the maintenance of the prisoners for the two years, ending June 30th, 1879, was

$391,980 94, the entire earnings of the Prison for the same period was but $100,269 56; and of this sum only $93,713 70 was for the labor of prisoners hired to contractors.

The remaining $6,555 86 of the earnings is credited as follows:

To drayage	$3,671 00
To wash-house	1,421 56
To shoe shop	1,072 92
To tin shop	390 38

These several sums represent a combination of labor and material, but in what proportions it is impossible to tell. From these statements it will be seen that not more than 25 per cent. of the maintaining cost of the Prison, during the last two fiscal years, was obtained from the labor of prisoners.

In the statement of Prison earnings, in the Warden's report, reproduced above, no account is taken of the labor of prisoners who have worked for the State. What the earnings of this labor would have been, at a fair valuation, I am not able to say, as on a great part of it, no valuation has ever been placed.

The Resident Director, in his report, expresses the opinion that the Prison might have been made self-supporting during the last two years, had it not been for the law which prohibited the letting of the labor of prisoners for less than fifty cents a day, while the Legislature refused or neglected to provide the means for employing it on State account. Without concurring fully in this opinion, I have no doubt the earnings of the Prison might have been very materially increased had the Directors been free to let the labor of the prisoners for whatever it would bring; or had an appropriation been made, and placed at their disposal, so that they could have set the prisoners to work on State account. No citizen has been more anxious to see the Prison placed on a self-supporting basis than have the Board who have had charge of it during the last four years; and it is but just to the Board to say that they have done everything in their power to induce manufacturers to hire prison labor.

The new Constitution provides a new system of management for the State Prison or Prisons. It is undoubtedly true, that it will always be impossible to secure satisfactory management of the prisons of a State, under a system which involves a change in all the officers and employés of the prison every few years. Successful prison management is possible only under a system, in which it will be possible to secure and retain the services of experienced, able, and faithful officers and employés.

The system, outlined in the new Constitution, contemplates permanency in the management. It provides for a Board of Prison Directors, who will hold office for ten years, but will be so arranged that one member will go out and another come in every second year. This constitution of the governing Board ought to secure a good degree of consistency and permanency in the policy which shall control in the management of the Prisons.

Another important feature in the government of the Prisons, provided for in the new Constitution, is the vesting of the Wardens with the power to appoint and remove, at pleasure, all other officers and employés except the Clerk. This is a very great power to place in the hands of a single individual, but, I think, a very proper and necessary one. In my opinion, such power must be exercised by

some one, to secure the proper government of a prison. But it is a power which should be entrusted only to a person of the very highest character, one endowed with many and varied intellectual and moral qualities, in a high degree. And I hazard nothing in predicting that the success or failure of the system of prison management, provided for by the new Constitution, will be due more to the character of the persons who shall be placed in charge of the Prisons, as Wardens, than to all other causes. Clothed with autocratic power, as they will be, they should possess that elevation and composure of character, that complete freedom from passion, prejudice, and bias, that will enable them to act with prudence, moderation, humanity, and absolute justice, under all circumstances.

Another important feature of the new system of prison management, now to be introduced, is the inhibition of prison labor, except on State account, after the first day of January, 1882. Although this inhibition will not operate legally till the date named, it will operate practically from this time forward, as it has in fact operated to some extent ever since the adoption of the new Constitution. With the certainty that no prison labor can be hired after two years from this time, it is not probable that practical business men will engage in new industries, based on the employment of prison labor. Before such industries could be fairly established they would have to be abandoned. It may be accepted then, as a fixed fact, that no contractor will hereafter want to hire prison labor with which to commence and prosecute a new industry. But more. It is reasonable to expect that those who are now employing prison labor will, at an early day, commence to draw their respective businesses to a close. A diminution in the demand for prison labor may be expected from this time forward till it shall entirely cease at or before the date fixed, when it shall be unlawful to hire out prisoners to contractors. This is the probable course which the demand for prison labor will hereafter take.

What does it suggest as to the duty of the Legislature? The biennial report of the Resident Director shows that during the last two years the Directors have been able to hire out to contractors less than 25 per cent. of the prisoners. It is quite certain they will not be able to let even as great a percentage in the future.

There will exist from this date almost as great reason for working prisoners on State account as there would if the inhibition against hiring their labor out was already in operation. In view of this fact it will be the clear and manifest duty of the Legislature to provide the Board of Directors with the means to employ the prisoners on State account, by making the necessary appropriations for the purchase of material, machinery, etc., for establishing and conducting such branches of manufacturing as may be determined on.

It is characteristic of all civilized and progressive peoples to desire to avail themselves of the knowledge and experience of older and more advanced communities. In fact the superiority and progressive character of a people shows itself in nothing more than in their disposition and capacity to appropriate and turn to account the results of the investigations and experience of others. I venture to suggest that, as we are about to enter on a new era of prison management in this State, it might not be amiss if steps were taken to place us in possession of the results of the study and experience of older States in the management of their penal and reformatory institutions.

The judicious expenditure of a small sum for this purpose might prove to be money well invested. The Directors who will have the labor and responsibility of managing our State Prisons ought to have the benefit of whatever knowledge has been acquired by experience in managing similar institutions elsewhere.

Upon the general subject of prison management, the evils of the inequality of sentences for crimes of substantially the same grade, and the pardoning power, I beg to refer to the views expressed in my biennial message to the last Legislature.

INSANE ASYLUMS.

The insane asylums rank first in importance among the charitable institutions of the State, both on account of the number and character of their inmates, and of the great cost at which they now are, and must always be, maintained. To make proper provision for the care and comfort of those who have suffered the unspeakable calamity of the loss of their reason, and to do, whatever science and experience have taught may be done, to restore them to their normal state, as respects their mental and moral faculties, may be classed among the highest and most sacred duties of a civilized people. It should be a cause of just pride to the people of this State, that the State has made such extensive and excellent provision for this unfortunate class of persons, as she has in the asylums at Stockton and Napa.

I take pleasure in saying that, in my judgment, both of these institutions are managed admirably.

The tax-payers of the State are interested in having these institutions, as well as all other public institutions, conducted as economically as practicable, consistent with the purposes for which they are maintained. Tried by the economical test, both our asylums for the insane must be pronounced not merely as fairly, but as highly, successful.

The per diem cost of maintenance of each patient at the Stockton Asylum was:

For the 29th fiscal year	43 cents.
For the 30th fiscal year	40 cents.

The average number of patients was:

For the 29th fiscal year	1,198
For the 30th fiscal year	1,170

The per diem cost of the maintenance of each patient at the Napa Asylum was:

For the 29th fiscal year	$55\frac{1}{6}$ cents.
For the 30th fiscal year	$44\frac{7}{12}$ cents.

The average number of patients was:

For the 29th fiscal year	$454\frac{1}{4}$
For the 30th fiscal year	$643\frac{1}{2}$

It would be natural to suppose *a priori* that the per capita cost of patients in an institution would decrease with the increase in the number of patients. We would then expect to find the cost per

capita less in an institution with 1,000 or 1,200 patients than in one with but 500 or 600 patients. The difference in the numbers in the Stockton and Napa institutions is perhaps sufficient to account for the difference in the per capita cost in the respective institutions.

In looking further, we find that at the Napa Asylum, with a yearly average of 454¼ patients for the 29th fiscal year, the daily per capita cost was 55½ cents, while with a yearly average of 643½ patients for the 30th fiscal year, the daily per capita cost was only $44\frac{7}{12}$ cents. It is probable that with 800 or 1,000 patients at Napa the per capita cost would not be above what it is at Stockton.

Dr. Wilkins, Resident Physician of the Napa Asylum, in his report to the Directors of that institution, has inserted a table showing the yearly per capita cost of the maintenance of patients in thirty-one institutions for the care of the insane in the principal States of the Union. Of those given in the table, there are only three in which the per capita cost is less than the per capita cost at Napa for the thirtieth fiscal year. These three are the Asylum at Stockton, in this State; the West Virginia Hospital for the Insane, at Weston, West Virginia, and the New York City Lunatic Asylum, at Blackwell's Island, New York.

It is proper to state that the per capita cost of the maintenance of patients, at both Stockton and Napa, as given above, embraces the entire cost of conducting the respective institutions, including board, bedding, and clothing for the patients, ordinary repairs of the buildings and machinery, and the salaries of the officers and wages of the employés.

The above exhibits demonstrate beyond question that executive ability of a high order is employed in the administration of each of these institutions. In the management of them the interests of the tax-payers are faithfully looked after and protected.

Are these institutions managed in other respects as they ought to be? As those who pay the taxes for their support have a right to demand that they shall be? And as those who are compelled to see their friends go to them, have so much cause to hope that they are?

To these questions I unequivocally answer, I believe they are. Both Dr. Shurtleff and Dr. Wilkins are gentlemen of high character, who have given the diseases of the mind, and the management and treatment of the insane, their special attention for many years. Their high character and their great attainments in their special line, furnish the highest guarantee we can have that the unfortunates under their care receive the best treatment that can be given. Each of these gentlemen is aided in his arduous work by learned, able, and humane assistants.

It will be observed that the Directors of the Stockton Asylum and the Trustees of the Napa Asylum ask for appropriations for their respective institutions.

The number of patients July 1st, 1877, was:

In Stockton Asylum	1,195
In Napa Asylum	395
Total	1,590

The number of patients July 1st, 1879, was:

In Stockton Asylum	1,127
In Napa Asylum	714
Total	1,841
Increase in two years	251

In two years more, if the rate of increase shall continue, there will be in the two institutions about 2,100 patients—at least 1,000 in each. The Stockton Asylum cannot accommodate 1,000 or 1,100 patients—it will probably still have the latter number—without using certain wooden and other buildings, which ought properly to have been supplanted by others long ago, and which nothing will justify the use of longer except the most absolute and imperative necessity.

And in the case of the Napa Asylum, it will, I presume, be absolutely impossible for it to accommodate the patients who will apply for admission during the ensuing two years, unless an appropriation shall be made for fitting up certain room, mentioned by the Resident Physician in his report to the Trustees, which has not yet been utilized.

I, therefore, respectfully commend to the careful and favorable consideration of the Legislature the requests of these Boards for appropriations with which to increase and improve the accommodations of their respective institutions.

REPORT OF THE DIRECTORS OF THE DEAF AND DUMB AND BLIND ASYLUM.

The report of the Directors of the Deaf and Dumb and Blind Asylum shows:

That the number of pupils in the institution June 30th, 1877, was		100
Admitted since		53
Total number during last two years		153
Graduated or discharged	27	
Died	1	
		28
Number in institution June 30th, 1879		125

That the total receipts of the institution for two years were	$87,952 85
Total disbursements	68,990 03
Balance	$18,962 82

The report asks that the appropriation for the support of the institution may be increased from $36,000 a year, the sum heretofore appropriated, to $40,000. It also asks for the appropriation of $148,000 for the erection of buildings and other purposes.

None of our public institutions is more strongly intrenched in the humane sentiments of the people than the Asylum for the Deaf and Dumb and Blind. And there is no one, I am sure, for whose support they contribute more willingly of their means. Hard-hearted and unfeeling indeed must be the man who begrudges the taxes he has to pay that the unfortunate deaf and dumb and blind children of the State may have unsealed to them the fountains of light and knowledge!

On the night of January 17th, 1875, the asylum building, a large and substantial stone structure, took fire, and was entirely destroyed. The Directors at once borrowed the necessary means, and erected a wooden structure, to be used till a building, or buildings, better adapted to the purpose, and more substantial in character, should be erected. The Legislature of 1875-76 appropriated $27,000 for the payment of the obligations the Directors had assumed in erecting such wooden building. It also appropriated $110,000 for the erection of a portion of a suitable building, in which to take care of and educate the deaf and dumb and blind children of the State—said portion of the building, to be thus erected, to have accommodations for 130 pupils, and the whole building when completed to accommodate 250 pupils, and not to cost over $175,000. The Directors, after mature consideration, came to the conclusion that it would be better to erect, instead of a single building with the capacity required, a number of separate and detached buildings. The plan which they adopted embraced four separate buildings to be so located as to form a quadrilateral. They erected two of these, called "Homes," at a cost of $90,986. At the session of the Legislature of 1877-78, the Directors asked for a further appropriation of $63,500, with which to build an additional "Home," and erect other necessary buildings, and procure an additional supply of water. Although a bill containing these appropriations, passed the Legislature, it failed to receive the approval of the Executive, because he could not approve these items without approving others also, which he did not think ought to be approved.

As, however, it was very necessary that certain other buildings should be erected, the Directors took the residue of the $110,000 appropriation, made by the Legislature of 1875-76, borrowed some $24,000 belonging to the General Fund and the Shop and Improvement Fund of the institution, and overdrew their account at the bank some $4,000 and over. From these sources they obtained $47,-664 71. Of this sum they expended in erecting buildings $30,648 47. The remaining $17,016 24 was used in furnishing the new buildings, procuring machinery, erecting gas-works, running a tunnel for water, etc. These expenditures were all judicious, and most of them absolutely necessary.

But it will be observed that of the $47,664 71 thus expended, only $19,014, the balance of the $110,000 appropriated for the erection of buildings, was properly applicable to these purposes. The other $28,660 71 was borrowed—$18,962 80 from the fund for the support of the Asylum; $5,370 04 from the Shop and Improvement Fund, and $4,317 85 from the Union Savings Bank.

The Legislature should appropriate the sums necessary to restore to these funds the amounts borrowed from them, and to pay to the Union Savings Bank the sum borrowed from it.

Whether the full $148,000 which the Directors ask for, with which to build another "Home" and other buildings, and make other improvements, should be appropriated I am not prepared to say. That some portions of it should be appropriated I have no doubt. But appropriations for public buildings and other public improvements should not be made in advance of the necessity for such buildings and improvements. Nor should such buildings and improvements be of a more expensive character than the uses to which they are to be put may fairly require.

I can only say that this institution is one of the most worthy of

our public institutions, that it should commend itself to the favorable consideration of the Legislature, and should receive such appropriations for buildings and improvements as may be necessary to enable it to meet fairly the demands on it.

If, as I recommend, an appropriation be made to enable the Directors to return the amount borrowed from the fund for the support of the institution, no increase in the appropriation for the support of the institution for the ensuing year, will be required. In fact, a much smaller sum will be sufficient.

It seems there was in the fund for the support of the institution, $18,962 82. This, the Principal says, in his Report to the Directors, was the accumulation of about ten years. It can hardly be regarded as in accordance with sound policy that an institution, supported from the public treasury, should be permitted to draw from the treasury in excess of its requirements, and thus be enabled to accumulate and keep on hand a large sum for which it can have no proper and legitimate use. I recommend, therefore, that only such sum be appropriated for the support of the institution, for the ensuing fiscal year, as may be necessary to supplement the sum already on hand, applicable to such purpose.

For full particulars concerning the institution I beg to refer to the report of the Directors and to the report of the Principal.

It gives me pleasure to say that I think the institution conscientiously, ably, and successfully conducted.

STATE UNIVERSITY.

For all matters connected with the State University I beg to refer to the biennial report of the Regents.

It should be the desire and ambition of the people of the State to see the University so full and complete in its facilities for furnishing instruction in all the various departments of science and literature, and so wise, able, and discreet in its management, that there may be neither occasion nor motive to send the youth of the State elsewhere to be educated. I can only advise that whatever power the Legislature may still have, under the new Constitution, to interfere with or control the affairs of the University, may be used, and wisely used, to this end.

STATE HARBOR COMMISSIONERS.

The biennial report of the Board of State Harbor Commissioners shows:

That the receipts from dockage, wharfage, tolls, and rents for the last two fiscal years were	$895,072 28
That the average monthly receipts were	37,294 68

That the receipts for the last two years—the rates being the same—have exceeded those of the two years ending—

June 30th, 1873	$527,575 76
June 30th, 1875	273,686 59
June 30th, 1877	92,774 38

These increased receipts are, doubtless, due, in part, to an increase of business at the port, but mainly, I presume, to a closer supervision by the Board over the details of the business under their control.

The report gives a detailed statement of the several improvements made during the period covered by it, for the better accommodation

of commerce, and the cost of each. It details, also, the action of the Board in the matter of the construction of the sea-wall and the progress that has been made in that important work.

During the last two fiscal years the Board, after defraying all current expenses, remitted a monthly average of between $23,000 and $24,000 to the Harbor Improvement Fund. Moreover, there was in that fund, on the 30th of June, 1879, $487,725 11.

About the time of the meeting of the last Legislature there was some discussion as to the policy of authorizing the Commission to issue bonds to construct the projected sea-wall. The plan, not being regarded with favor by the Governor, was not brought forward. However plausible the project for issuing bonds with which to push the construction of the sea-wall might have appeared at that time, the experience of the last two years, I think, has fully satisfied the Board that it will be able to derive from its present sources of revenue sufficient means to construct the sea-wall as rapidly as the public interests will require.

It is to be hoped that no project of this character will find favor with the present or any future Legislature, unless it shall be demonstrated, beyond all cavil or doubt, that not to construct the sea-wall more rapidly than can be done from the surplus in the Harbor Improvement Fund, supplied as at present, will be a public calamity.

I need pass no words of eulogy on the Commissioners for their fidelity and efficiency in the discharge of their duties. The exhibits of their report do that more eloquently than it can be done by any mere words. It is to be sincerely hoped, however, that the State may always have in places of great public trust, men as honest and capable and efficient as these have shown themselves to have been.

BANK COMMISSION.

In my biennial message to the last Legislature, I recommended legislation for the better protection of depositors in savings' banks. In response to this recommendation the Act was passed, entitled "an Act creating a Board of Bank Commissioners, and prescribing their duties." The provisions of the Act apply to all incorporated banks, commercial as well as savings.

In pursuance of this Act, Commissioners were appointed on the 1st of May, 1878, who forthwith organized as a Board, and, in obedience to the requirements of the Act, commenced the exercise of the powers with which they were vested. The banks, I believe without exception, recognized the power of the Legislature to create the Commission, and to endow it with such powers as were conferred in the Act creating it; and furnished the Commission with all reasonable facilities for making the examinations of their respective affairs, required by the Act.

The law requires the Commission to make a report to the Governor on or before the 30th day of June in each year. In pursuance of this requirement, the Commission have made their first annual report, which includes statements of the condition of each incorporated banking institution at the close of business on the 30th of June and 31st of December, 1878; also, statements of the condition of each when examined by the Commissioners, and such statistical and other information as in their judgment might be of interest to the public.

The information contained in this report is both interesting and

useful; but it must be much less interesting and useful than it would be if the condition of the banks which it details was more recent. It will be observed that the report is made on the 30th of June, 1879, while the latest period at which it reports the condition of the banks is December 31st, 1878.

Under the law each bank, in existence when the law went into operation, is required to report to the Commissioners twice a year, to wit, within thirty days after the expiration of its semi-annual fiscal term; and each bank which has been or shall be organized subsequently to the passage of the Act, is required to have its semi-annual fiscal terms expire on the last day of June and of December in each year, and to report, on the 20th day of July, its actual financial condition on the preceding 30th day of June, and on the 20th of January its condition on the preceding 31st of December.

I would recommend that all incorporated banks—those incorporated before as well as those incorporated after the passage of the Bank Commissioner Act—be required to make their semi-annual fiscal terms close on the 30th of June and the 31st of December; and to report to the Commissioners their actual financial condition on the 30th of June, on the following 20th of July, and their actual financial condition on the 31st of December, on the 20th of January following. It may be that their fiscal terms correspond now with the periods above indicated; and if so they could make their semi-annual reports on the dates named without inconvenience.

The Commissioners should then be allowed, after the receipt of reports, sufficient time in which to examine them and collate the information they contain before making their report to the Governor. Thus would system be introduced into the operations and reports of the banks, the work of the Commission would be much simplified, and the reports of the Commissioners, when made, would contain full information concerning the condition of the banks at the latest practicable dates.

The law, also, requires that the Commissioners shall make a general report of the transactions of their office to the Legislature, during the first week of each session. In the event that the Legislature should deem it judicious to change the time at which the Commissioners shall be required to make their report to the Governor, in accordance with the suggestions above, might it not be wise to provide, also, for merging the report now required to be made to the Legislature into the one required to be made to the Governor. Thus, all attainable information concerning the condition of the banks would be procured and laid before the Governor and the Legislature, as well as before the public, in the best practicable form, at the smallest possible cost.

The Commissioners, in their report to the Governor, say that they deem it best to postpone, till they make their report to the Legislature, all suggestions as to amendments to the banking laws of the State, believing that during the six months that will elapse between the former and the latter they will become better qualified to judge what changes are needed.

Without knowing what changes they will recommend, I have that implicit faith in the integrity of their character, the soundness of their judgment, and their practical sense, that I feel I risk nothing in urging on the Legislature to give to their recommendations its careful and considerate attention.

The Bank Commission had its origin in a desire to give greater security to depositors in banks, and particularly to the depositors in savings banks. The depositors in the savings banks are composed largely of people whose time is occupied in labor, from morning till night, and from the beginning of the week to the end of it; who have not the time in which to inform themselves as to the condition of the banks in which they deposit their savings; and who, many of them at least, have not the intelligence to procure the necessary information about the banks, even if they had the time. The first consideration with these people in making their deposits is, or at least should be, that they shall be safe, absolutely safe; the second, that the deposits shall yield as large a return in interest, or dividends, as shall be compatible with their absolute safety. It is proper that the State should interpose to secure these desiderata for these people, as far as practicable. And I have not the slightest doubt that the Bank Commissioners, through the exercise of the powers conferred on them, and through the moral power, which their right to examine and expose all irregular or doubtful transactions of the banks, if there should be such, exerts, have made all banks, both savings and commercial, more conservative in character, and safer depositories for the funds of their customers. I believe it to be the general verdict of all classes, the bankers included, that the operation and effects of the Bank Commission have been, so far at least, in a high degree salutary and beneficial.

REPORT OF THE TRANSPORTATION COMMISSIONER.

Under the Act of April 1st, 1878, creating the office of Transportation Commissioner, prescribing its powers and duties, etc., I appointed the Honorable B. F. Tuttle, a gentleman well and favorably known throughout the State for his integrity and ability, Transportation Commissioner. He has, with great energy and assiduity, devoted himself to the duties of his office. The transactions of his office, and the results of his study and investigation of the problems connected with the transportation of the State, he has embodied in a report, which, in pursuance of law, he will present to the Legislature.

The lateness of the hour at which I was able to obtain a copy of the printed report, has prevented me from making any close examination of its contents.

The railroad problem is one of the most important, as well as one of the most difficult ones, with which we have to deal.

Under the new Constitution, however, the power over railroad and other transportation companies, which, under the old, was vested exclusively in the Legislature, is transferred mainly to the Railroad Commission.

The power of the State to prescribe what transportation companies may charge for their services, where such power has not been surrendered by contract with the companies, is no longer open to question. The decision of the Supreme Court of the United States in the Granger cases, so-called, has settled that question finally and forever.

This State, in the most formal and authoritative manner which it is possible for a State to adopt, has declared her intention to exercise this power. This declaration was made in the adoption of the new Constitution.

The Supreme Court of the United States, in the Granger cases,

decided not merely that a State possesses the power to prescribe what transportation companies may charge for carrying passengers and freight, but that this power is essentially a legislative power; that the Legislature may prescribe, in advance, what the companies may charge, and that when the Legislature has once exercised this high legislative prerogative, no alternative is left to the companies but to obey.

The new Constitution has created a Commission in which is vested the legislative power to prescribe what transportation companies shall charge for their services, which, under the old Constitution, belonged to the Legislature alone, and which, perhaps, belongs to the Legislature in every other State in the Union. Under the old Constitution the Legislature possessed the power to prescribe rates for transportation, but it was left to the discretion of the Legislature whether it would exercise this power or not. No such discretion is left to the Commission created by the new. The language of the Constitution is: "The Commissioners shall have the power, and *it shall be their duty*, to establish rates of charges for the transportation of passengers and freight by railroad or other transportation companies." The State has declared that her power in the premises shall be exercised.

Now on what principle should the Commission proceed in prescribing the rates which transportation companies may charge? Manifestly the rates should be fixed with reference to producing a sufficient sum:

First—To pay operating expenses.

Second—To keep the roads, equipments, etc., in repairs.

Third—To pay a reasonable interest on the money actually invested in the construction and equipment of the road, etc.

Capital invested in the construction of and in operating railroads is entitled to a reasonable return equally with capital invested in other enterprises. The public, however, have a right to demand that the transportation companies shall not exact more for their services than what may be a reasonable return on the capital invested.

It is clear that the office of Railroad Commissioner will be no sinecure, if the Commission shall intelligently and earnestly attempt to do exact justice between the transportation companies and the people.

The Legislature will, I have no doubt, render to the Commission, in the discharge of their very onerous and responsible duties, all the aid in its power, by enacting such laws as may be deemed necessary or proper in the premises.

INSURANCE COMMISSIONER'S REPORT.

The eleventh annual report of the Insurance Commissioner shows, in detail, the condition and business of the insurance companies organized under the laws of this State, and, in tabulated form, that of the companies of other States and foreign countries doing business in this State, for the year ending December 31st, 1878.

The provisions of the new Constitution, concerning corporations, will make necessary a revision of the laws touching insurance, and particularly of those prescribing the terms and conditions on which insurance companies, organized under the laws of other States or of foreign countries, may do business in the State.

The Legislature will doubtless exercise that care and moderation in making the changes required by the fundamental law which the

magnitude of the interests, to be affected by the changes, would seem to require.

FISH COMMISSIONERS REPORT.

I beg to invite the attention of the Legislature to the fifth biennial report of the Fish Commissioners, a paper of unusual interest and value, on account of the vast amount of information it contains, not merely concerning the transactions of the Commission during the last two fiscal years, but also concerning the extent and value of the fish catching and canning industries in this State and on other parts of the coast, and the species of fish caught in the bays and rivers of California and sold in the San Francisco markets. The appropriations which have, from time to time, been made and placed at the disposal of the Fish Commissioners have, in my judgment, been wisely made and judiciously expended. It is doubtful if any other sums, of no greater amounts, appropriated from the State treasury, have been productive of equally valuable results. The Legislature will, I have no doubt, make an appropriation of such sum to continue the work in which the Commissioners are engaged, as, after investigation of the subject, they shall deem necessary for the purpose. The people of the State owe a debt of deep gratitude to the members of the Commission for their intelligent and persevering labors, without pecuniary compensation, to preserve the food fish which were indigenous to the waters of the State, and to introduce into these waters the most valuable species found in the waters of other countries.

STATE BOARD OF HEALTH.

The State Board of Health have presented their fifth biennial report, which, with the report of the Secretary to the Board, embracing papers on various subjects, I respectfully commend to the consideration of the Legislature.

This Board is engaged in collecting facts, found in as many and varied localities in the State as practicable, and collating them with the view of determining the causes of disease in such localities, and of ascertaining how these causes may be removed or neutralized, and disease thus prevented, or at least lessened, and its virulence mitigated. It is difficult to conceive that any investigations should have a greater interest for the general public than those which are prosecuted for the special purpose of ascertaining the causes of diseases, how diseases may be prevented, and how the sanitary condition of the country may be improved.

The work in which the Board is engaged should secure for it and its recommendations the friendly consideration of the Legislature.

REPORT OF YOSEMITE VALLEY COMMISSIONERS.

The report of the Commissioners to manage the Yosemite Valley and the Mariposa Big Tree Grove gives a statement of the transactions of the Commission, during the last two fiscal years. The Commissioners have done all that it has been in their power to do, with the small means at their command, to erect bridges and make other improvements in the valley, necessary for the acommodation of visitors. I think it would be well, if the policy were adopted, of making an appropriation of a few thousand dollars, at each session of the

Legislature, to be used in making and keeping in repair roads and trails, and in other improvements, which would make points of interest, in and about the valley, more accessible, and thus add to the comfort and safety of the pilgrims who travel thither to worship at that shrine of Nature where she reveals herself in her grandest forms. Thus in a comparatively short time, without ever imposing a burden which would be felt by the taxpayer, roads and trails would be constructed, over which the traveler would be able to reach every point of interest, with ease and safety, and without the payment of toll.

I commend this matter to the favorable consideration of the Legislature.

STATE LIBRARY.

The biennial report of the Trustees of the State Library shows that the number of volumes in the library was:

On June 30th, 1877	45,478
As follows:	
In the General Library	31,917
In the Law Library	13,561
On June 30th, 1879	49,159
As follows:	
In the General Library	34,398
In the Law Library	14,761
Total additions in the last two fiscal years	3,681

The Trustees remark: "It is believed that the character of the books added has been superior to that of former years, a larger proportion being standard works of permanent value."

STATE ENGINEER DEPARTMENT.

The last Legislature passed an Act, approved March 29th, 1878, creating the office of State Engineer. It, also, provided for the appointment of two consulting engineers. The Act defines the powers and prescribes the duties of the State Engineer, and of the consulting engineers.

The salary of the State Engineer was fixed at $6,000 a year, and by the terms of the Act he was required to report to the Legislature on the 1st of January, 1880. As the Legislature was not in session on that day, he was not able to comply with that provision of the law, but he will, I presume, make his report to the Legislature as soon as it shall be ready to receive it.

I appointed to the office of State Engineer Wm. Hammond Hall.

The Act provided that the consulting engineers should receive for their services not exceeding $3,000 a year each. I appointed, as consulting engineers, General B. S. Alexander and Colonel G. H. Mendell, officers in the Engineer Department, U. S. A. Before appointing them, however, I arranged with them that they should receive only $1,800 a year each. My object was to save a part of the appropriation for the payment of the consulting engineers, that it might be used to procure the services for a short period of still another engineer of large experience and reputation, if it should be deemed expedient to do so.

The State Engineer entered on the duties of his office on the 1st day of May, 1878. After consultation with the consulting engineers

he organized the necessary parties, under skilled engineers, to make the observations and surveys, and collect the data required by the Act. He has been engaged in this work, and in arranging and classifying the information obtained, and in studying the problems, submitted by the Act for solution, up to the present time. The results he will give in his report to the Legislature.

Colonel G. H. Mendell has continued to occupy the position of a consulting engineer to the present time. General B. S. Alexander held the other position of that character till his death, which occurred in December, 1878.

In July following, I tendered the position of consulting engineer, made vacant by the death of General Alexander, to Captain James B. Eads, of St. Louis, Missouri, which he accepted, subject to certain conditions, as to his compensation and the time he would be required to spend here. Owing to a trip he has since made to Europe, and perhaps also to other causes, he has not yet been able to visit the State.

It would be impossible to overstate the magnitude or importance of the interests involved in the irrigation, reclamation, and debris problems. It is with these problems that the State Engineer Department has to deal. The debris and reclamation problems are to a considerable extent, though not wholly, identical problems. While it is not true that reclamation would not have been necessary if there had been no debris from the mines, it is undoubtedly true that reclamation is both more necessary, and more difficult to accomplish, in consequence of such debris.

THE DEBRIS QUESTION.

At present there seems to be an irrepressible conflict between the mining and agricultural interests of the State. The farmers of the valleys claim that, under the principles of the common law, they are entitled to have the streams and rivers which descend from the mountains, pass by their farms, in substantially the same condition in which they would be, if the debris from the mines was not run into them. The miners on the other hand assert that their mines would be valueless if they did not have the right to use the waters, as they use it, to separate the gold from the dirt, and to carry the dirt away; and that when the government sells mineral lands, it not only guarantees to the purchaser the right to take the gold from such land, but guarantees to him also, impliedly at least, the right to use such water as he may be able to obtain, in separating the gold from the dirt, and in carrying off the dirt, so that it shall not prove an obstruction. The farmers have invoked the process of the Courts to prevent the miners from running their debris into the streams. In the meantime, the miners continue their hydraulic processes, by which the mountains are washed down, as if there were no rivers to be filled with sand, no farms to be covered fathoms deep with mud and gravel, and no bays to be injured, if not eventually to be destroyed, for the purposes of navigation.

If the common law can be made available by the farmers for their purpose, it will mean the utter stoppage of mining by the hydraulic process. I cannot but think that this would prove a calamity; a calamity not alone to those who have their capital invested in such mining, and to the laborers who are employed in it, but a calamity to

the world at large. It would reduce the production of the precious metals, which would be a serious calamity to the whole civilized world; and the calamity would be in proportion to the falling off in the gold production.

On the other hand, if the farmers, in their attempt to assert their alleged common law right, should not succeed in stopping the miners from running their debris into the streams, what will be the prospect ahead? Will not the miners be free to fill up the rivers and bays with the debris from their mines, without let or hindrance, in the future, as they have been in the past?

Under the present laws then we must have one of two results: If the farmers succeed in applying their common law remedy, hydraulic mining must cease. If they do not, hydraulic mining will be prosecuted in the future, under the same conditions and with similar results, though probably much more serious in character, as it has been in the past.

Is it not possible to devise some plan by which the property and rights of the farmers may be protected; the great mining industry, through which commerce gets its supply of the precious metals, may continue to be prosecuted; and the rivers and bays of the State be saved to navigation?

I most respectfully suggest that it would be better, in the present juncture, for the farmers and miners to meet each other in the halls of legislation than in the forum of the Courts.

This whole subject I commend to the most earnest consideration of the Legislature.

CHINESE IMMIGRATION.

In pursuance of an Act approved December 21st, 1877, entitled "An Act to ascertain and express the will of the people of the State of California on the subject of Chinese immigration," the question of the continuance or the prohibition of Chinese immigration was submitted to the voters of the State at the general election held on the 3d day of September last. At said election the vote was:

Whole number of votes	161,405
For Chinese immigration	883
Against Chinese immigration	154,638
Voters who did not vote on the question	5,884

This vote shows that the people of this State are substantially unanimous in their opposition to Chinese immigration. A popular vote, however, was not required to satisfy any one residing in the State, with the ordinary opportunities for observation, that such was the actual condition of public sentiment on this question.

It is fortunate, however, I think, that the popular sentiment on this question has been permitted to express itself at a general election. Though there was no doubt in the mind of any intelligent person who had resided or spent any considerable time in this State as to the condition of public sentiment on this subject, there was, somehow, a strange misapprehension in the public mind east of the Rocky Mountains, as to what it was. The impression seems to have obtained widely there that the opposition to Chinese immigration was limited to the poorer and more ignorant classes, and particularly to those of foreign birth, and to politicians, who pandered to these classes for the purpose of securing their votes. No impression more

erroneous could have obtained. The vote at the September election demonstrated, what every intelligent person residing in the State knew before, that the opposition to Chinese immigration was limited to no class, but embraced nearly the entire population. Our brethren east of the Rocky Mountains will no longer have any excuse for not understanding the position of the people of this State on this subject.

But why is it necessary or desirable that the position of the people of this State, or this Coast, on this question should be understood by the people on the other side of the continent? It is because we can obtain effectual relief from the evils of Chinese immigration only through the action of the Federal Government. And to secure such action, we will be compelled to get a preponderance of the public sentiment of the whole country into harmony with ourselves on this question. When it becomes definitely and authoritatively known, that the opposition to the Chinese in this State, and on this Coast, is not limited to a class—and that class the least intelligent—but embraces substantially the whole people, irrespective of classes, we may expect that this opposition will receive respectful consideration from the people of the whole country.

The new Constitution seems to assume that the State may prohibit the immigration of an undesirable class of foreigners into her borders, and directs the Legislature to provide the necessary legislation to prohibit the introduction into the State of Chinese.

It is my opinion, that all hopes of getting rid of the Chinese, or of stopping Chinese immigration, which are based on the assumed power of the State to deal with the question, will prove illusory.

The State should use, whatever police powers she possesses, to mitigate the evils flowing from the presence of the Chinese among us; but, in my judgment, the Federal authority alone, is competent, under our form of government as it has been construed by the Supreme Court of the United States, to deal with the question of the immigration of foreigners to this country.

REGISTRY LAW.

The object of a registry law is—at least, should be—to secure all, who are entitled to the elective franchise, in its exercise, and to prevent those who are not entitled to the franchise from exercising it. In other words, it should be a means of protecting the ballot-box from frauds. If a registry law fails to accomplish this, or in so far as it fails to accomplish it, it fails to accomplish the only purpose for which such a law can legitimately exist. It is the opinion of many intelligent citizens, who have observed closely the operation of the present registry law, particularly in towns where the voters are not generally known by their fellow-voters and by the officers of the election, that it, so far from proving an obstacle to illegal voting, actually furnishes facilities for such voting.

All good citizens desire that only legally qualified voters shall be permitted to vote at elections, and that no such voter shall be permitted to vote more than once at any election. It is suggested that the great number of names on the Great Register of a county, as such registers are retained from year to year, after the persons bearing such names have removed from the county, or, as in many instances, have died, furnish exceptional facilities for voting by persons who are not qualified, or for voting more than once by persons

who may be qualified to vote. It is believed that voting on the names of persons who have removed from the county or have died, and whose names have not been canceled on the Great Register, is a serious evil in all the larger towns of the State. If this belief is well founded—and there is much reason to think it is—the evil should be promptly and effectually remedied.

I invite the earnest attention of the Legislature to this subject.

INDEBTEDNESS OF SWAMP LAND DISTRICTS.

The last Legislature passed a concurrent resolution requesting the Governor to prepare a cause to be prepared for the information of the present Legislature a statement of the unpaid indebtedness of the several swamp land districts, organized by the State Board of Swamp Land Commissioners, and of the available assets of such districts.

The information called for by the resolution will be found on page 9 of the Controller's report.

The resolution further asks that the Governor shall recommend what he may deem the proper method of paying such indebtedness.

I must confess that I have not sufficiently informed myself as to the circumstances of the creation of this indebtedness, nor of the causes which have prevented its payment, to state what would be a just and equitable method of paying it.

COMMISSION TO PREPARE AMENDMENTS TO EXISTING LAWS.

It must have occurred to all thoughtful persons, and particularly to all persons connected in any way with the administration of the laws, that the adoption of the new Constitution had made necessary a very great number of changes in the existing body of laws, to make them harmonize with that instrument. Moreover, it must have occurred to all persons who took the trouble to reflect on the subject, that a great many of these changes, perhaps a large majority of them, must be purely formal in their character, about which no question of policy could ever arise. Though the bulk of the amendments to existing laws, which are necessary to bring such laws into harmony with the new Constitution, are purely formal in character and involve not in the slightest degree any question of public policy, yet it is a matter of the greatest public importance that they be made, and correctly made.

Many gentlemen of the very highest character and attainments, with no other interest in the matter than that possessed by every citizen, suggested to Mr. Perkins, the Governor-elect, and myself, that we would be conferring a great boon on the State if we would prevail on some suitable and competent gentlemen to undertake the work of preparing such amendments to existing laws as were made necessary by the provisions of the new Constitution. It was urged by these gentlemen that this work should be undertaken by persons properly qualified by education and experience, and prosecuted in a systematic manner. Otherwise it would be done only in a slovenly and fragmentary way, and many of the most necessary amendments would be liable to be omitted. These omissions could not fail to cause much trouble and be productive of great evil.

Concurring entirely in the general scope of these views, the Gov-

ernor-elect and myself determined to solicit three gentlemen to undertake this work. The gentlemen selected were Judge I. S. Belcher, Judge Thomas P. Stoney, and Honorable A. C. Freeman. Their names are a sufficient guarantee of their personal integrity, their professional ability, and their qualifications for the work they were desired to perform.

Neither the Governor-elect nor myself, nor both together, had any power to appoint these gentlemen to do this work. All we could do was to request them to do it. They accepted our invitation, and undertook the work.

They have performed the work which they undertook, and I have no doubt have performed it faithfully and well. They concurred with me in the opinion that it would not be politic for them to prepare bills on subjects involving questions of public policy, or on subjects about which there would be sharp or radical differences of opinion; and accordingly they have limited their labor to preparing amendments to laws made necessary by the new Constitution; and in drawing new bills also made necessary by the new Constitution, but which involve no question of policy, and about the necessity of which there can be no differences of opinion.

It is not claimed that their work has any official character, or that the Legislature is under any official or legal obligation to accept it at their hands. It is claimed, however, that if they have done their work well—and I have the utmost confidence that they have—the interests of the State will be subserved by the Legislatures accepting it, and enacting into laws the bills which they have prepared. Though the Legislature is under no official obligation to accept the work of these gentlemen, it may be under a moral obligation to accept it.

As the Governor-elect and myself could not bind the State to accept the results of their labor, no more could we bind it to pay them for their labor. It rests with the Legislature to say whether the State will accept the results of their labor, and whether it will pay them for their labor. If the Legislature accepts what they have done, it will, also, no doubt, pay them reasonably for their time and labor expended. I commend the whole matter to the candor of the Legislature.

CONCLUSION.

I have now discharged the duty imposed on me by the Constitution, by giving to you such information concerning the condition of the State, as has seemed to me pertinent and appropriate, and by making such recommendations as I think the public interests require. It remains with you to take such action in relation to the matters recommended, and in relation to such other matters as shall come before you, as you shall think the public good to require. You are a separate and distinct branch of the government, and, in the discharge of your proper functions, act independently of the other departments, and are responsible for your official acts only to your consciences and public opinion.

My official relations with the government of the State are about to terminate. For the past four years and more, I have occupied the honorable, onerous, and responsible position of Chief Executive. My official acts have passed into the domain of history. The power now vested in me will shortly pass to my successor. He will sustain

to you the relation which I sustained to the two preceding Legislatures.

In him, you and the people will find, I am sure, an able, upright, and conscientious Chief Executive, whose chief ambition will be to use the great powers of his office to protect the rights and promote the interests of all alike.

Permit me to express the sincere and earnest hope that the relations between the Legislature and the Executive may be of the most cordial character, and that they may work together in harmony to promote the public good.

WILLIAM IRWIN, Governor.

APPENDIX TO GOVERNOR'S MESSAGE.

PARDONED FROM STATE PRISON.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Alfred Foster	Marin	Burglary	December, 1876.	Three years.

Decision.—Whereas, one John Winters, a co-defendant with the said Alfred Foster in the trial for burglary, has made a statement exonerating the said Foster from all participation in the said crime; and, whereas, the District Attorney who prosecuted the said Foster, and the Judge before whom he was tried, referring to the statement of the said Winters, say: "We have carefully considered the said statement, together with the evidence taken on both trials, and have come to the conclusion that the statement of Winters is correct, that Alfred Foster is an innocent man, wrongly convicted by circumstantial evidence which is now explained. We would therefore pray that said Alfred Foster be immediately pardoned and released." December 11th, 1877.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Thomas Sylvester	Sacramento	Forgery	January, 1877	Two years.

Decision.—Whereas, an application for the pardon of the said Thomas Sylvester is now made by the Honorable H. W. Severance, Consul of the Hawaiian Government, at San Francisco, of which government Sylvester is a subject; and, whereas, the District Attorney who prosecuted, and the Judge who sentenced the said Thomas Sylvester, advise his pardon; and, whereas, the aforesaid H. W. Severance, Hawaiian Consul, engages to have the said Sylvester returned to his own country, if he shall be pardoned; now, therefore, for the reasons stated in the application for the pardon, and in the letter of the Judge who sentenced and the District Attorney who prosecuted him, advising his pardon, this pardon is granted on the express condition that the subject thereof forthwith leave the State and remain absent therefrom at least five years from the date of this discharge. December 24th, 1877.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Daniel Buckley -----	Tehama--------	Murder 2d degree-	May, 1874------	------ Ten years.

Decision.—Whereas, the pardon of the said Daniel Buckley is now asked for in a petition numerously signed by prominent citizens of Tehama County, which petition is also signed by the Hon. Charles F. Lott, before whom, as Judge of the Second Judicial District, the said Daniel Buckley was tried; and whereas, in the petition thus signed the following statement occurs: "The undersigned further represent that since his conviction new evidence has been discovered, which was not produced on behalf of said Buckley at the trial, and neither the defendent Buckley nor his counsel were aware of its existence, at the time of, and not until long after his trial and conviction, which, if produced at the trial, your petitioners believe would have established his innocence beyond a doubt, of the charge against him;" and whereas, Jerome Banks, Esq., who, as District Attorney of Tehama County, prosecuted the said Daniel Buckley, recommends his pardon, not however, because he thinks that if the evidence mentioned in the petition of citizens of Tehama County and Judge Lott had been introduced at the trial, the prisoner would not have been convicted, "but solely because, in his judgment, the said Daniel Buckley has been punished sufficiently to meet the demands of justice." February 7th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Joseph Casey--------	San Francisco --	Forgery, etc.------	January, 1875 --	--- Eleven years.

Decision.—Whereas, the pardon of the said Joseph Casey has been asked for by a large body of citizens, resident in San Francisco and elsewhere, and was recommended by the State Prison Committees of the Senate and Assembly of the Legislatures of 1875-76, and by nearly all the members of said Legislature; and whereas, his pardon is advised by Judge Blake, of the Municipal Criminal Court of the City and County of San Francisco, who tried and sentenced him, and who, in a letter advising such pardon, says: "Not very long after the above date (date of sentence) I became satisfied, from information which I considered reliable, that Joseph Casey was less criminal than I at first supposed. I did not doubt his guilt—there could be no question about that—but I concluded he had nothing to do with originating the 'poll-tax forgeries,' and that his position in connection with them was that of a subordinate. I concluded that he would have had no connection with those forgeries if he had not been controlled by others, and that he might properly be pardoned at the end of three years;" and whereas, the Honorable Thos. P. Ryan, who was District Attorney of the City and County of San Francisco at the time of the conviction of the said Joseph Casey, and the Honorable Robert Ferral, who was Assistant District Attorney, and the Honorable Delos Lake, who was associated with the District Attorney in the prosecution of the said Casey, and Captain I. W. Lees, Captain of the Detective Police of the City and County of San Francisco, all unite in advising the pardon of the said Joseph Casey, basing their advice on facts and considerations identical, or similar to, those above quoted from the letter of Judge Blake; and, whereas, the said Joseph Casey has now served three full years on his sentence in the State Prison; and whereas, in my judgment, neither the demands of justice nor the interests of society require his further punishment. February 28th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
P. J. Bugbee --------	San Francisco--	Forgery ---------	November, 1876-	----- Four years.

Decision.—Whereas, an application has been made for the pardon of the said Bugbee, indorsed by many of the leading citizens of San Joaquin County, in which he was brought up, and where his parents now reside; and whereas, his pardon is asked for by the Joint Committee of the Senate and Assembly on pardons; and whereas, he was quite young—under twenty years—when the crime of which he stands convicted was committed; and whereas, the circumstances under which the crime was committed, indicated weakness in the criminal, rather than a fixed and irreclaimable wickedness of desperation; and whereas, there is hope that he may reform and be a useful citizen, this beiug his first offense; and whereas, his parents, who enjoy the esteem of all who know them, are bowed with shame over his disgrace, and are grieving themselves to death over his incarceration. April 3d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Amy Green	San Joaquin	Grand larceny	March, 1877	Two years.

Decision.—Whereas, the pardon of the said Amy Green is now asked for by numerous persons, including the prosecuting witness; and whereas, the said Amy Green is a subject of Her Britanic Majesty, and has a home, children, and other relations in Australia; and whereas, the Honorable William Lane Booker, Her Majesty's Consul in the City of San Francisco, has undertaken to have the said Amy Green, if she shall be pardoned, returned to her home in Australia, by a steamer which is to sail from San Francisco on the 15th instant. Pardoned on the condition that she leave the State of California. April 12th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Edward Murphy	San Francisco	Assault with a deadly weapon	June, 1857	One year.

Decision.—Whereas, the sentence against the said Edward Murphy has never been executed; and whereas, in consequence of an effort now being made to have the said Murphy placed in the State Prison in pursuance of said sentence passed upon him, an application has been made to have him pardoned; and whereas, I. W. Lees, Captain of the Detective Police of San Francisco, in a letter on file in this office, says: "I would respectfully inform your Excellency that I knew Mr. Murphy for several years prior to the act of which he was convicted; and that he was and has always been an exemplary citizen. Furthermore, the offense was committed under circumstances that might occur to any citizen. Since that time he has lived in the city and has uniformly been a peaceable and law-abiding citizen, and has never been known to commit an act at variance with any law of the country." Now, therefore, without assuming to decide that the said Murphy was not properly convicted and sentenced, nor that the sentence should not have been executed, according to its terms, the fact, first, that the sentence has been permitted to remain unexecuted for nearly twenty years, and second, that during the whole of this period the said Murphy has been living openly in San Francisco, where he could have been arrested any day, and has deported himself as a good and law-abiding citizen, suggest the question as to whether the purposes for which punishment is inflicted require this penalty now to be executed. I do not think they do. April 16th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Eduardo Quevedo	San Francisco	Burglary	July, 1876	Four years.

Decision.—Whereas, the pardon of the said Quevedo is now asked for by numerous respectable citizens and residents of San Francisco, among whom is the Honorable M. G. Pritchard, acting Consul of the Mexican Government at said city, who engages to have the prisoner, in the event of his pardon, returned immediately to Mexico, of which country he is a citizen; and whereas, there does not appear to be any sufficient reason why the prisoner should not be pardoned and discharged from prison on the condition that he forthwith, on his discharge, leave this State and the United States, and never return thereto. This pardon is granted on the express condition that the person pardoned shall forthwith leave this State and the United States, and never return thereto. April 30th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
James Carroll	Contra Costa	Murder, 2d degree	July, 1873	Twenty years.

Decision.—Whereas, the Joint State Prison Committee of the Legislature of 1875-76 recommended the said James Carroll to the favorable consideration of the Governor, and called his

attention to the papers on file in the Executive office bearing on the subject, and the Joint State Prison Committee of the Legislature of 1877-8 has recommended a commutation of sentence; and whereas, seven of the jurors who brought in the verdict of murder in the second degree against the said James Carroll, have signed a petition for his pardon, intimating a doubt as to his guilt; and whereas, conceding that the said Carroll committed the homicide, it does not appear that he acted with malice or premeditation, but under the excitement incident to a street brawl, in which all parties were under the influence of liquor, and hoping the punishment he has already suffered may operate effectively to keep him out of bad company in the future; and whereas, the said Carroll has a most devoted wife, who has labored unremittingly for his pardon ever since his conviction, and whose health has given way under the trials and anxiety to which she has been subjected, and who, it is evident, cannot much longer endure the strain upon her emotions, caused by the continued imprisonment of her husband. May 3d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Walter Resley	San Joaquin	Burglary	April, 1875	Five and one-half years.

Decision.—Whereas, the pardon of the said Walter Resley is now asked for by a large number of the leading citizens of San Joaquin County, including the District Attorney who prosecuted him; that whereas, this was the first offense of which he was guilty; that at the time of its commission he was under twenty years of age; that he has now served three full years on his sentence; that his conduct during this period has been exemplary; and whereas, believing that, when the criminal is young and is being punished for his first offense, he is most likely to be reformed by a comparatively short term of imprisonment than by a long one; and whereas, the said Resley has a mother in the State of Texas who has exhibited, during his imprisonment, the utmost anxiety for his release and reformation, and has forwarded the means with which he may return home. This pardon is granted on the express condition that the person pardoned shall forthwith leave the State and remain absent therefrom till the expiration of the five and a half years for which he was sentenced. May 8th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
J. T. Blunt	Tulare	Felony	May, 1876	Three years.

Decision.—Whereas, the pardon of the said Blunt is now asked for by the prosecuting witness and a large number of the leading citizens, including most of the county officers of the county in which the crime was committed; and whereas, the conduct of said Blunt, since he has been in prison, has been such as to furnish the strongest possible guarantee that he will be a good law-abiding citizen hereafter. July 3d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John Mayer	Los Angeles	Assault with a deadly weapon	September, 1877	Two years.

Decision.—Whereas, the pardon of the said John Mayer is now asked for by the Judge before whom he was tried, and by whom he was sentenced, by the District Attorney of the county, by the Judge of the Judicial District, by most, if not all, the county officers, and many of the leading citizens of the county, the said pardon being asked for by the said parties on the ground that the act for which the said Mayer was convicted, was committed by another person, as appears by their petition on file in this office. July 3d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Ah Quong ----------	Placer ---------	Robbery ---------	March, 1877 ----	------Two years.

Decision.—Whereas, the pardon of the said Ah Quong is now asked for by W. H. Bullock, District Attorney, who prosecuted the said Ah Quong, by John M. Fulweiler, who was assistant counsel for the people, and by Judge J. Ives Fitch, who sentenced him; and whereas, they set forth in their petition, now on file in this office, that, from information received since the conviction of the said Ah Quong, "they have reason to believe, and do believe, that the prosecuting witness in the case, Gim Yim, did not swear to the truth in his evidence against the said Ah Quong; and that therefore said Ah Quong was wrongfully convicted of said crime, and is now suffering imprisonment for a crime he was not guilty of, and should therefore receive a pardon." July 12th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Davis ------	San Francisco --	Manslaughter ----	September, 1875-	------Ten years.

Decision.—Whereas, the pardon of the said William Davis was recommended by the subcommittee on State Prison affairs of the late Legislature; and whereas, the Honorable Samuel H. Dwinelle, District Judge of the Fifteenth Judicial District, before whom the said Davis was tried, and by whom sentenced, says in a letter now on file in this office: "Measures are being taken to procure his (Davis') pardon, and your Excellency will be importuned in that behalf. From the fact that I entertain doubts as to his guilt, and think the homicide for which he was convicted was in all probability committed in necessary self-defense, I cordially join with those who are seeking to obtain a pardon, in recommending that it be granted. I have carefully examined the evidence at the trial as reported by the short-hand reporter, and make the above recommendation after consideration and deliberation;" and D. J. Murphy, Esq., present District Attorney of the City and County of San Francisco, who assisted in the defense of the said Davis at the trial in which he was convicted of manslaughter, says: "I understand that an effort is now to be made to obtain his (Davis') pardon, and I cheerfully join in asking executive clemency in his behalf for the reasons hereinbefore stated, and because I honestly believe he ought never to have been convicted, and is now serving out an unjust term of punishment." July 13th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
George F. Allen -----	Yuba ----------	Grand larceny----	April, 1878-----	One and one-half years.

Decision.—Whereas, the pardon of the said George F. Allen is now asked for by many of the leading citizens of Marysville, including the District Attorney who prosecuted him; and whereas, it is shown by the certificate of the State Prison Physician, now on file in this office, as ground for the said pardon, that the health of the said George F. Allen is such that he cannot recover, and cannot be expected, judging from the progress the disease has already made, to live more than a week or two at the farthest, while he may die in the course of four or five days. July 25th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John Kelly ---------	El Dorado------	Grand larceny and housebreaking--	January, 1875 --	-------Six years.

Decision.—Whereas, the said John Kelly has conducted himself in an exemplary manner during his imprisonment, and has now only between six and seven months of his term to serve; and whereas, he did come to the aid of officer Varney, when the latter was attacked by an insane prisoner, and was, in all probability, the means of saving his life; and whereas, I

deem it right and proper that such meritorious conduct on the part of a prisoner should have due recognition. July 31st, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Wm. W. Armstrong	San Joaquin	Burglary, 2d degree	September, 1877	Two years.

Decision.—Whereas, the said Wm. W. Armstrong has now served, including credits for good conduct, one year on his sentence, and has conducted himself in an exemplary manner during that period; and whereas, the said Wm. W. Armstrong was but fourteen years of age when the offense of which he was convicted was committed; and whereas, he seems to be of a kind disposition and well disposed, thus giving ground for hope that he will lead an honest and upright life in the future. August 6th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Peter Carr	Santa Clara	Felony	May, 1874	Ten years.

Decision.—Whereas, the pardon of the said Peter Carr is petitioned for by the Judge who sentenced him, and was recommended by the Joint Committee of the Senate and Assembly of the last Legislature; and whereas, the District Attorney who prosecuted, and the Sheriff who arrested the said Carr, state, in a letter now on file in this office, that they are satisfied that he was led into the commission of the crime, for which he is now suffering, by one Hamilton, his co-defendant, who had previously served a term in the State Prison; and whereas, the said Carr was a mere youth when the crime for which he is now undergoing punishment was committed, the said crime was, so far as known, the first he had ever committed, and the time he has already served, including credits for good conduct, is equivalent to a sentence of about five and a half years. August 12th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Harry Lewis	Inyo	Grand larceny and robbery	July, 1875	Five years.

Decision.—Whereas, the said Harry Lewis has now but a few months of his sentence to serve; and whereas, the District Attorney of Tulare County has asked that he be pardoned, on the ground that his testimony is wanted, and is deemed material in a trial for murder, which is about to take place in the said County of Tulare. September 7th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Frank G. Selby	Yuba	Manslaughter	January, 1877	Four years.

Decision.—Whereas, the prison physician, in response to an application made by me for information touching the physical and mental condition of the said Frank G. Selby, has made the following statement, to wit: "The case of Frank G. Selby, a prisoner in San Quentin, has become serious; he is partially insane at this time, and his mental disease is rapidly approaching completeness. On critical examination I find that he has functional derangement of the heart of a serious character and cerebral meningitis. To this disease is to be attributed his derangement of intellect. This disease is not now severe, but is chronic and progressive. Two weeks ago he was relieved from confinement in the yard and cell, and assigned to the stable building, day and night, without favorable results, and he has even become materially worse mentally during

that time. He is now partially insane, beyond question, and will inevitably become worse from day to day, while laboring under the mental aggravation of his confinement. It is not even certain that his discharge will arrest the progress of the disease, but it seems to me to be necessary in any view of his case that the experiment should be tried, and he be delivered to the care of his family. Then as a legitimate deduction from the premises, I recommend his immediate discharge from prison as the most necessary step to prevent permanent insanity;" and whereas, the offense for which the said Frank G. Selby is now in prison was his first offense, and was committed under such circumstances as to make it a matter of some doubt as to whether he should have been convicted, as appears from letters now on file in this office of several prominent lawyers who heard the evidence in the case; and whereas, his parents, who are most estimable persons, are extremely anxious about his condition, and most desirous to do whatever can be done, by medical aid or otherwise, to avert the fate of complete and permanent insanity which now threatens him. September 10th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Silas Garrison	Fresno	Assault with intent to commit rape	September, 1876	Six years.

Decision.—Whereas, the pardon of the said Silas Garrison is now asked for by W. H. Creed, Esq., District Attorney, who prosecuted, and Honorable Gillum Bailey, the Judge who tried and sentenced him, who, in a letter on file in this office, say: "Your Excellency's petitioners respectfully show that heretofore, to wit: at the September term of the County Court, held in the Town of Fresno, in and for the County of Fresno and State of California, one Silas Garrison was tried and convicted of the crime of assault with intent to commit a rape, and was, on the 22d day of September, 1876, sentenced to imprisonment in the State Prison for the term of six years, where he is now confined; that your petitioners are respectively, the Judge of the County Court of said Fresno County, and the District Attorney of said county, and tried the said Garrison, and are familiar with the evidence that was adduced upon his trial; that the said Garrison, previous to the time of the preferment of the said charge against him, sustained a good and unblemished character, both in this State and the State of Iowa, where he resided previous to his immigration to this State in the year 1873, and that upon the trial he established an unimpeachable character, and that the said Garrison is a young man. Wherefore, upon a full consideration of all the facts and circumstances of the case, developed on the trial, together with other facts and circumstances that have come to light since the trial, your petitioners are of the opinion that if the said Garrison was guilty as charged, he has been sufficiently punished, and ought to be pardoned and released from imprisonment. And the premises considered, your petitioners recommend the said Silas Garrison to your Excellency's most tender mercy, and pray that he may be pardoned and released from further imprisonment." November 19th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John Hausty	Sacramento	Burglary	January, 1878	Two years; as appears from the certified copy of the judgment delivered to the Warden of the State Prison, at the time of the delivery of the prisoner at the State Prison.

Decision.—Whereas, the Hon. R. C. Clark, County Judge of Sacramento County, who sentenced the said John Hausty, now says the sentence was for only one year, as appears from his minutes, and that the clerk, in making up the records of the Court, which show the sentence to have been for two years, must have committed an error, and adds that his own recollection of the

matter is fortified by the statement of Charles Jones, District Attorney at the time, who says he distinctly recollects that the sentence of the said Hausty was only for one year (see letter on file in this office); and whereas, the said R. C. Clark, County Judge, etc., asks that a pardon may be issued to the said John Hausty, to the end that his term of service in the State Prison may be in pursuance of the sentence actually passed on him, and not the one erroneously certified to in the copy of the judgment delivered to the Warden of the prison. November 29th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John McCormick	Los Angeles	Grand larceny	November, 1876	Ten years.

Decision.—Whereas, the pardon of the said John McCormick is now asked; and whereas, the statements now on file in this office of the District Attorney who prosecuted, and the attorney (appointed by the Court) who defended him, make his guilt a matter of grave doubt; and whereas, there is much reason to believe that he will conduct himself in an orderly and upright manner, if discharged. December 9th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
A. B. Stevens	San Joaquin	Burglary	November, 1877	Two years.

Decision.—Whereas, the pardon of the said Stevens is now asked for by numerous respectable citizens of San Joaquin County, including the County Judge who sentenced and the District Attorney who prosecuted him—such being asked for on the ground that the health of said Stevens is such that he is liable to die in the course of a few weeks, and that it is hardly possible for him to survive more than a few months, and that he may be taken charge of and cared for by his relatives; and whereas, there is now on file in this office a certificate of the prison physician confirming the statement of the petitioners touching the health of the prisoner; and whereas, it is stated that the sister of the prisoner is now waiting to remove him from the State if he shall be pardoned. This pardon is granted on the condition that the said A. B. Stevens forthwith leave the State and not return thereto. April 30th, 1878.

By virtue of the authority in me vested by the Constitution and laws of this State, I, William Irwin, Governor of the State of California, do hereby pardon the said A. B. Stevens, described above. December 14th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Charles Thomason	Siskiyou	Grand larceny	January, 1877	Four years.

Decision.—Whereas, the pardon of the said Thomason is now asked for by numerous citizens of the county in which his crime was committed, including the jurors who convicted him; and whereas, there is reason to believe that his crime may have been due, in part, at least, to a mental malady from which he suffered, both prior and subsequent to its commission; and whereas, the prison physician gives it as his opinion that he has entirely recovered from such malady, and that his faculties are now in their normal condition. January 4th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Burton	San Benito	Grand larceny	August, 1878	Two years.

Decision.—Whereas, the pardon of the said William Burton is now asked for by the District Attorney who prosecuted, and ten of the jurors who tried him, and by most, if not all, of the county officers, on the ground that, owing to facts disclosed since his conviction, they do not believe him guilty. (See petition on file in this office.) March 8th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Tibbetts ----	Tulare ---------	Grand larceny ----	September, 1878-	-------One year.

Decision.—Whereas, the jurors, except three, two of whom are away from the State, who convicted the said Tibbetts, and the District Attorney who prosecuted him, now ask for his pardon, on the grounds set forth in their petition on file in this office. May 1st, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Charles E. White----	Shasta ---------	Burglary---------	January, 1878 --	-------One year.

Decision.—Whereas, the pardon of the said White is petitioned for by a large portion of the people of the locality in which the offense was committed, including many of the most intelligent and respectable citizens of the county; and whereas, the circumstances of White's offense, as proven on the trial, and a statement of the District Attorney who prosecuted him (which statement is concurred in by the Judge before whom he was tried—see papers on file in this office), make it extremely probable that he intended to commit only malicious mischief, for which the severest punishment that could have been inflicted on him would have been imprisonment for six months in the County Jail, and a fine of five hundred ($500) dollars. June 7th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Charles Stevens -----	Alameda-------	Burglary---------	April, 1879 -----	------Two years.

Decision.—Whereas, the pardon of the said Charles Stevens is now asked for by numerous citizens, both on account of the circumstances under which the crime was committed and his extreme youth, he being represented by his father but sixteen years of age; and whereas, the Judge who sentenced him, in a letter now on file in this office, says: "In the matter of the boy, Charles Stevens, who is about to apply for a pardon, I had nothing to guide me in passing sentence, except the fact of the plea of guilty, and, as usual in such cases, I sentenced him to two years; I felt desirous at the time, on seeing such a young man before me, of searching into his antecedents, but his reticence and refusal to tell who or where his parents were, prevented this, and of course operated against him. I find now that his reticence was a worthy effort on his part to try to save his parents from mortification. * * * * * * * Had I been aware of all the facts, as they have since come to me, I think I should have caused the charge to have been reduced to petit larceny. In this view of the case, it is quite probable that the penalty which the youth has now suffered is quite as severe as any I should have inflicted had I been aware of all the facts at the time, for which, however, no one is at fault;" and whereas, the District Attorney who prosecuted him concurs in the above statement of the Judge, and adds his belief that the case is one in which Executive clemency should be exercised; and whereas, the father of the said Charles Stevens has promised that, in the event of his pardon, he will remove him forthwith from the State and place him in school among relatives in the State of New York, and require him to remain there two years from the date hereof. This pardon is granted on the express condition that the subject thereof shall forthwith leave the State and not return thereto under two years from the date hereof. July 14th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
George M. Farr	Sacramento	Assault with a deadly weapon	October, 1878	Eight months, and pay a fine of $250, and to be imprisoned at the expiration of said eight months until the fine is paid at the rate of $2 per day.

Decision.—Whereas, the said George M. Farr has now served the eight months in the County Jail to which he was sentenced; and whereas, he has no money with which to pay the fine which the sentence of the Court imposed on him in addition to imprisonment in the County Jail; and whereas, his pardon is now asked for by most, if not all, the county officers, including the Judge who passed sentence on him, who set forth in their petition on his behalf that "he being a locomotive engineer, has been of great service in running the steam engine for heating the Court-house, and has saved the county fifty cords of wood." August 2d, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
George W. Mansfield	San Francisco	Burglary		Three years.

Decision.—Whereas, the said George W. Mansfield did serve in the State Prison the term of his sentence, and was discharged therefrom on the 26th day of October, 1861; and whereas, the said George W. Mansfield has now conducted himself for many years as a good and useful member of society; and whereas, there is every reason to believe that the said George W. Mansfield is thoroughly reformed, and that he will continue to deport himself as a well-disposed person and useful member of the community. September 2d, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
James P. Smith	El Dorado	Robbery	December, 1875	Twelve years.

Decision.—Whereas, very soon after the delivery of the said James P. Smith at the State Prison, William Irwin, as the Executive of the State, vested with the pardoning power, promised him a pardon before the expiration of my term of office, on the following conditions, to wit: First, that he, the said Smith, should be exemplary in his conduct, and obedient to the rules established for the discipline of the prison during his imprisonment; second, that he should assume the responsibility of conducting the brickyard at such times as the Directors of the prison should determine to employ prisoners at making brick, and take charge of, and work such prisoners in the making of brick as should be assigned him, and use his best endeavors to get good and faithful service from the prisoners placed under his control, and his best judgment and skill in making and burning brick; third, that he should make no attempt to escape from the prison grounds, nor connive at any attempts to escape by any prisoner under his control; fourth, that he should forthwith, on his discharge from the prison, leave the State and the Pacific Coast; fifth, that he should, after his liberation, desist from the commission of all crime of whatsoever character, and particularly highway robbery, and deport himself as an orderly and law abiding person. And, whereas, the said James P. Smith has faithfully, and, as I am informed and believe, to the best of his ability observed and performed the first, second, and third of the conditions above set forth; and whereas, his fidelity to his plighted word in the past, inspires me with, I think, a well grounded confidence that he will observe the fourth and fifth conditions above set forth; and whereas, his marked ability as a manager of prisoners, his practical knowledge of the brick-making business, and his fidelity to the important interests confided to him, have been of great pecuniary value to the State. September 8th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Charles Anderson ----	Alameda-------	Burglary 2d degree.	April, 1877-----	------Two years.

DECISION.—Whereas, the said Charles Anderson was discharged from the prison on the 5th day of January, 1879, without being pardoned; and whereas, the testimony of the said Charles Anderson is represented to be necessary to the ends of justice in cases now pending in the Courts of justice of the State of Nevada; and whereas, an unpardoned felon is not permitted by the laws of said State to testify in the Courts of justice thereof. October 6th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
H. Pantoskey -------	Alameda-------	Perjury ----------	January, 1879--	---- Three years.

DECISION.—Whereas, the pardon of the said H. Pantoskey is now asked for by eleven out of twelve of the jurors who tried (the twelfth, it is said, was not accessible), the District Attorney, and his assistant, who prosecuted, the Judge who sentenced him, and by many of the leading citizens of the county in which the crime was committed, for reasons set forth in detail in their petition now on file in this office. November 11th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
C. A. Newton -------	Colusa ----------	Forgery ----------	October, 1878---	-------Six years.

DECISION.—Whereas, the pardon of the said C. A. Newton is now asked for by the Judge who sentenced, and the District Attorney who prosecuted him, and by the great body of citizens of the Town of Colusa, where the crime was committed, for the reasons set forth in their petition, now on file in this office; and whereas, I am of opinion that under the circumstances, as they have been detailed to me, a sentence for one year in the State Prison would have been a sufficient punishment for the crime. November 11th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Giacomo Buero------	San Francisco --	Manslaughter ----	October, 1875---	---- Seven years.

DECISION.—Whereas, the pardon of the said Giacomo Buero is now asked for by ten of the trial jurors who convicted him, who say in their petition of date June 23d, 1877, now on file in this office: "Said verdict (verdict of manslaughter, with recommendation of mercy to the Court) was rendered upon the condition that after a few months' imprisonment, we would all join in a petition for the pardon of defendant. * * * Wherefore, we, in accordance with the agreement made in the jury room at the time said verdict was agreed upon, and believing that the defendant has been sufficiently punished, join in this petition for his pardon;" and whereas, in a letter dated November 19th, 1879, now on file in this office, Charles B. Darwin, Esq., who, as Assistant District Attorney, took a leading part in the prosecution of the said Buero, and the Honorable Saml. H. Dwinelle, who, as Judge of the Fifteenth District Court, tried and sentenced him, advises his pardon; and whereas, he now has less than seven months of his term to serve. November 24th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
F. Burr	Nevada	Embezzlement	November, 1879	One year.

Decision.—Whereas, the pardon of the said Frank Burr is asked for by the prosecuting witnesses and other prominent citizens of Nevada County, in a petition now on file in this office, in which the circumstances of the offense are detailed and the grounds stated on which the pardon is asked; and also by the District Attorney who prosecuted and the Judge who tried and sentenced him, who, in a letter now on file in this office, say: "In addition to a petition circulated in our vicinity for the pardon of Frank Burr, who has pleaded guilty to embezzlement at this term of our County Court, we deem it proper to submit our views separately, in recommending him to Executive clemency. Under all the circumstances presented to us, and from sources entitling them to our consideration, we should have been fully satisfied if any mode could have been adopted rather than prosecution. It seems to us to be one of the few cases where prosecution seems to be a misfortune rather than benefit. The party convicted has, ever since the commission of the offense (some five years since) lived a quiet and respectable life, and has gained the confidence and respect of his community, which has not lessened by reason of his arrest. As we are informed, he was not entirely conscious of the consequences of his act, he absolutely refusing any technical defense with others, cause us to believe him governed by principle in this matter. From all we can learn and are willing to act upon, we believe this to be one of the cases where the interposition of Executive clemency is fitting; and from our knowledge and information we feel justified in earnestly recommending his pardon." November 25th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Martin Carty	San Mateo	Assault to murder	July, 1876	Three years.

Decision.—Whereas, at the expiration of his term, to wit: on the 28th day of October, 1878, the said Martin Carty was discharged but not pardoned; and whereas, he now applies to be pardoned, that he may avail himself of the rights of an American citizen with respect to the public lands of the United States; and whereas, it does not appear that the public interests will be, in any way, affected injuriously by granting such pardon. November 26th, 1679.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
H. W. Hyde	Tuolumne	Manslaughter	November, 1876	Seven years.

Decision.—Whereas, the pardon of the said H. W. Hyde is now asked for by the District Attorney who prosecuted, and the Judge who tried and sentenced him, and by eleven of the jurors who found him guilty, the other juror being dead, for the reasons set forth in their petition on file in this office; and whereas, large numbers of leading citizens of the locality where the homicide was committed, other than those above mentioned as having official connection with the trial and conviction of the said Hyde, have heretofore earnestly sought his pardon. December 17th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John W. Lewis	Lassen	Incest and abortion	November, 1874	Thirteen years.

Decision.—Whereas, the pardon of the said John W. Lewis is now asked for by C. McClasky, who, as County Judge, tried and sentenced him, by E. V. Spencer, who, as District Attorney, prosecuted him, and by H. C. Stockton, foreman of the jury which convicted him, for the reason, principally, that since the conviction of the said Lewis facts and evidence have come to light which create a serious doubt in their minds as to whether Lewis was guilty of the crimes

of which he was convicted (see their petition on file in this office, in which the evidence discovered, and the facts that have transpired since the conviction of Lewis, which have caused them to doubt his guilt, are set forth at great length and with great particularity of statement); and whereas, the official relation of all the parties to the trial of the said Lewis was such that it should not only enable them to judge accurately of the bearing of subsequently discovered testimony, or of acts transpiring subsequently, on the question of his guilt, but should also furnish a guarantee of their honesty and impartiality in any statement they might make on the subject. December 22d, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
M. F. Harley	Alameda	Battery	October, 1879	A fine of $500 or imprisonment for 500 days.

Decision.—Whereas, the pardon of the said W. F. Harley is now asked for by many of the best and most prominent citizens of Oakland, including the Judge who sentenced him, and the District Attorney of the county, on the ground that the sentence was disproportioned to the offense, and that the punishment already inflicted is sufficient to satisfy the demands of justice. December 30th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Alfred Ver Mehr	San Francisco	Embezzlement	May, 1877	Six years.

Decision.—Whereas, the pardon of the said Alfred Ver Mehr is now asked for by a large body of the leading citizens of San Francisco; and whereas, his aged parents who are most respectable and worthy people, not only suffer great mental anguish on account of his disgrace and imprisonment, but are in actual and imminent need of his services to aid them in procuring the necessaries of life; and whereas, I have great confidence that he will hereafter lead an honest life, and be a useful member of society, and will aid in the support of his aged and infirm parents. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Scott	San Francisco	Grand larceny	October, 1879	One year.

Decision.—Whereas, the pardon of said William Scott is now asked for by the District Attorney who prosecuted, and the Judge who tried and sentenced him, on the ground that, in their opinion, it was not his intention to commit a larceny. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Henry Thompson	San Francisco	Uttering and passing a counterfeit gold bar	March, 1877	Four years.

Decision.—Whereas, the pardon of the said Henry Thompson is now asked for on the ground that he knows where certain property of great value was feloniously secreted in the State of Nevada, and promises, if pardoned, to point out to the owners of such property the place where it may be found; and whereas, the said Thompson has behaved well in the prison, and now has only about four months more to remain. This pardon is granted on the condition that the said Thompson forthwith, on his discharge, leave the State and never return thereto. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Lodi Brown	Sonoma	Murder, 2d degree	February, 1872	Thirty years.

Decision.—Whereas, the pardon of the said Lodi Brown is now asked for, on the grounds: First, that he was quite young at the time or the commission of the crime, and was, it is believed, led into its commission by another and older person, who escaped punishment by turning State's evidenee; second, that he has been exemplary in his conduct ever since he has been in the prison, and has rendered valuable service to the State as an assistant in the prison drug store; third, that there is reason to believe that he has resolved to live an honest life hereafter, and that if given his freedom, before all hope in his bosom is extinguished, he will seek a new home and endeavor to pursue an honorable course; and, fourth, that he has already served, including the eredits to which he is entitled for good conduct, the equivalent of a term of twelve years. This pardon is granted on the express condition that the said Lodi Brown forthwith, on his discharge from the prison, leave the State, and not return thereto before April 29th, 1890, the date at which his term would expire under the existing laws with regard to credits. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Newton Morgan	San Francisco	Forgery	January, 1875	Fifteen years.

Decision.—Whereas, the pardon of said Newton Morgan is now asked for by a numerous body of leading citizens of San Francisco County who, in their petition say, "that including credits for good conduct and a commutation of three years for meritorious services rendered at the time of the burning of the prison shops, nearly ten years of the original fifteen years have been exhausted; that during his imprisonment, the said Newton Morgan has conducted himself at all times in an exemplary manner, rendering good and efficient services in a clerical capacity; that in our opinion, he has been sufficiently punished for his offense, and would, if restored to freedom, become a useful member of society." And whereas, I know, of my own personal knowledge, that the said Morgan has served the State faithfully and efficiently, whilst he has been in the prison; and whereas, I believe that no public interests require that he should undergo longer imprisonment. January 3d, 1880.

REPRIEVE OF SENTENCE.

Name of Prisoner.	County.	Crime.	Sentenced.	Penalty.
John Runk	San Francisco	Murder, 1st degree		Death.

Decision.—Whereas, in the District Court of the Fourth Judicial District of the State of California, in and for the City and County of San Francisco, one John Runk was convicted of the crime of murder in the first degree, and the judgment of the said Court being that the said Runk shall suffer death; and wheraas, a warrant has been issued by the Court, directing you (the Sheriff of the City and County of San Francisco) to execute the said judgment of the Court upon said John Runk, on the 29th day of March, A. D. 1878.

Now, therefore, these presents are to direct you to suspend the execution of the warrant aforesaid until Friday, the 19th day of April, A. D. 1878, on which last-named day you will execute the said warrant of the said Court, unless you are further restrained by competent authority. March 22d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Penalty.
John Runk	San Francisco	Murder, 1st degree		Death.

Decision.—Whereas, in the District Court of the Fourth Judicial District of the State of California, in and for the City and County of San Francisco, one John Runk was convicted of the crime of murder in the first degree, and the judgment of said Court being that the said Runk shall suffer death; and whereas, a warrant has been issued by the Court, directing you (the Sheriff of the City and County of San Francisco) to execute the said judgment of the Court upon said John Runk, on the 29th day of March, A. D. 1878.

And whereas, on the 22d day of March, 1878, I directed you to stay the execution of the said warrant until Friday, the 19th day of April, 1878.

Now, therefore, these presents are to direct you to further suspend the execution of the warrant aforesaid until Friday, the 26th day of April, A. D. 1878, on which day you will execute the said warrant of the said Court upon the said John Runk, unless you are further restrained by competent authority. April 19th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Penalty.
F. A. Sprague	Ventura	Murder		Death.

Decision.—Whereas, in the case of the People of the State of California vs. F. A. Sprague, in the District Court of the First Judicial District of the State of California, for the County of Ventura, the said F. A. Sprague was found guilty of the crime of murder, and a judgment of death was rendered against him by said Court; and whereas, a warrant, signed by the District Judge of the said District Court, has been delivered to you as the Sheriff of Ventura County, wherein you are directed, as said Sheriff, to execute the said judgment of death upon the 5th day of December, A. D. 1879; and whereas, I have this day granted to the said Sprague a reprieve from the said judgment of death until the 6th day of February, A. D. 1880. Now, therefore, I, William Irwin, Governor, do hereby direct you, the Sheriff of said Ventura County, to suspend the execution of the said judgment of death, and of the said warrant issued thereupon, until Friday, the 6th day of February, in the year 1880, on which day, unless you are further restrained by competent authority, you will proceed to execute the said judgment of death, and the warrant issued thereupon. November 15th, 1879.

COMMUTATION OF SENTENCE.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
J. W. Graham	Colusa	Forgery	July, 1877	Two years and six months.

Decision.—Whereas, a petition for the pardon of the said J. W. Graham, signed by the District Attorney who prosecuted, and the Judge who sentenced him, and by numerous other prominent citizens of the county in which the crime was committed, which petition is now on file in this office. And for the reasons set forth in the aforesaid petition for his pardon. Let his sentenced be commuted to one year and six months. September 7th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Williams ___	Stanislaus _____	Robbery ________	October, 1871 __	___ Fifteen years.

Decision.—Whereas, Benjamin Doyle and Charles Moore, who were jointly indicted with the said William Williams for the same offense, received a sentence of but ten years each; and whereas, the proof of the guilt of Doyle and Moore was more direct and conclusive than that of the guilt of Williams, and there were no circumstances in the case of the latter calculated to aggravate his offense, which did not exist in an equal or greater degree in the case of the former; and whereas, it is not in accordance with justice or sound policy to visit persons guilty of the same offense, committed under the same circumstances, with different degrees of punishment, unless for special reasons, which do not appear to exist in the present instance. Let his sentence be commuted from fifteen years to eleven years, all credits which the said William Williams may have heretofore acquired by reason of good conduct to remain the same as if this commutation had not been granted. October 22d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
George A. Griffin ____	Alameda _______	Burglary 1st degree ___________	September, 1877 _	Two years and three months.

Decision.—Whereas, it is alleged that the said Griffin had been guilty of a certain social wrong before his conviction of the crime of burglary—the nature whereof is partially indicated in the papers on file in this office; and whereas, the Judge who sentenced, and the District Attorney who prosecuted him, and the President of the railroad company on whose cars his burglaries were committed, advise his pardon that he may have the opportunity to repair the said social wrong of which he is alleged to have been guilty. Let his sentence be commuted, so that it will expire on the 23d day of January, 1879. December 27th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
B. Bonnett __________	San Francisco __	Assault with a deadly weapon _	March, 1879 ____	Pay a fine of $500, or be imprisoned in the County Jail not exceeding two hundred and fifty days.

Decision.—Whereas, the Hon. M. C. Blake, Judge of the Municipal Criminal Court, who sentenced the said Bonnett, now advises, for the reasons set forth in his letter on file in this office, that the said sentence be commuted to $200 fine, or in default of payment of such sum to imprisonment in the County Jail one hundred days. Let his sentence be commuted to the payment of a fine of $200, or, in default of payment of such fine, to imprisonment in the County Jail for one hundred days. May 9th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Daniel Haley ________	San Francisco __	Robbery _________	March, 1871 ____	___ Twenty years.

Decision.—Whereas, the Honorable T. W. Freelon was Assistant District Attorney and the Honorable Delos Lake Judge of the Municipal Criminal Court of the City and County of San

Francisco at the time the said Daniel Haley was convicted of the crime for which he is now suffering imprisonment, and the former, as such Assistant District Attorney, prosecuted, and the latter, as such Judge of the Municipal Criminal Court, sentenced him; and whereas, the said T. W. Freelon and Delos Lake now ask that the said Daniel Haley may be pardoned, or his sentence commuted to a term of thirteen years, as appears by their petition, now on file in this office, in which they say: "We are respectively of the opinion that the sentence in the case of Daniel Haley is excessive, and would earnestly and sincerely pray that you may pardon or commute him to a term of thirteen years, to the end that he may be released at an early day." Let his sentence be commuted to thirteen years. June 16th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
George F. Wilson	San Francisco	Robbery and prior conviction of petit larceny	March, 1874	Life.

Decision.—Whereas, the Hon. M. C. Blake, Judge of the Municipal Criminal Court, before whom the said George F. Wilson was tried, has written to me, under date of June 9th, 1879, as follows (see his letter, on file): "On the 11th day of April, 1874, George F. Wilson and John Scott, upon a conviction of the crime of robbery and a prior conviction of petit larceny, were, in the Mnnicipal Criminal Court of this city and county, sentenced to imprisonment in the State Prison for life. If I could have fixed the term, at discretion, it would not have been longer than seven years, which fact I noted in my minutes at the time. If these two men have behaved well during their imprisonment, I think it would be proper to pardon them when they have, with their credits, completed a term of seven years, and I hope your Excelleney will be pleased to pardon them when they have completed such term. It may be that a seven years' term has already expired. If so, I hope they will be pardoned immediately." Let his sentence be commuted to seven and one-half years. June 16th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John Scott	San Francisco	Robbery and prior conviction of petit larceny	March, 1874	Life.

Decision.—Whereas, the Hon. M. C. Blake, Judge of the Municipal Criminal Court, before whom the said John Scott was tried, has written to me, under date of June 9th, 1879, as follows (see his letter, on file): "On the 11th day of April, 1874, George F. Wilson and John Scott, upon a conviction of the crime of robbery and a prior conviction of petit larceny, were, in the Municipal Criminal Court of this city and county, sentenced to imprisonment in the State Prison for life. If I could have fixed the term, as discretion, it would not have been longer than seven years, which fact I noted in my minutes at the time. If these two men have behaved well during their imprisonment, I think it would be proper to pardon them when they have, with their credits, completed a term of seven years, and I hope your Excellency will be pleased to pardon them when they have completed such term. It may be that a seven years' term has already expired. If so, I hope they will be pardoned immediately." Let his sentence be commuted to eight years. June 16th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Jones	Tuolumne	Murder, 2d degree	July, 1872	Fourteen years.

Decision.—Whereas, the Judge who sentenced the said Jones has addressed to the Executive a communication, now on file in this office, in which he says: "I am informed that the friends of Mr. Jones, convicted of murder and now in the Penitentiary, have applied for a pardon. I have been informed that Jones is quite advanced in years and in very poor health, and though I do not think his sentence unjust, yet, in consideration of his age and sickness, I recommend a favorable consideration for his petition." Let his sentence be commuted to eleven years and six months. June 17th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Henry Marshall	San Bernardino	Grand larceny	May, 1873	Ten years.

DECISION.—Whereas, the Warden of the prison has advised that, in his judgment, the discipline of the prison will be promoted by a commutation of the sentence of the said Henry Marshall. Let his sentence be commuted by deducting therefrom the full period of six months. June 17th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Charles F. Martin	San Bernardino	Robbery	January, 1877	Five years.

DECISION.—Whereas, the pardon of the said Charles F. Martin is now asked for by numerous citizens of San Bernardino County, including all the members of the jury that convicted, the District Attorney who prosecuted, and the Judge who sentenced him; and whereas, in view of the extreme youth of the said Martin, he being at the time of conviction but twenty years of age, his sentence may have been severer than the demands of justice and the public interests required. Let his sentence be commuted to three years and six months. August 1st, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Andrew R. Phillips	Los Angeles	Assault to murder	May, 1872	Eighteen years.

DECISION.—Whereas, the pardon of the said Andrew R. Phillips is now asked for by the District Attorney who prosecuted and the Judge who sentenced him, as well as by numerous other citizens, on the ground that his sentence was excessive. Let his sentence be commuted to twelve years. August 2d, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John H. Coffey	Sacramento	Felony	January, 1877	Three years and six months.

DECISION.—Whereas, an order of Court was made on the following day, to wit: on the 23d of March, 1877, by virtue of which the said John H. Coffey was detained in the County Jail, as a witness for the prosecution in the case of The People vs. H. A. Caulfield, for eighteen days, the said order having been discharged on the 9th day of April ensuing, and another order made directing the Sheriff to take and deliver him to the authorities of the State Prison. Let his sentence be commuted by deducting therefrom eighteen days. September 27th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Granville Millsap	Santa Clara	Murder, 2d degree	September, 1873	Fifteen years.

DECISION.—Whereas, the pardon of the said Granville Millsap is now asked for by numerous prominent citizens of the County of Santa Clara, where the crime for which he is imprisoned was committed, and of the County of Tulare, where his relatives reside, including the District Attorney who prosecuted him; and whereas, though his sentence may have been excessive, the

law itself fixes the lightest sentence which may be passed on one convicted of murder in the second degree, at imprisonment in the State Prison for ten years; and whereas, it has not been shown, nor even alleged, that the said Granville Millsap was not guilty of the crime of which he was convicted; and whereas, while I do not think the Executive should exercise his power of pardon or commutation to reduce sentences below the limit prescribed by the law itself, there is much reason to believe that, in the present case, no good purpose will be subserved by requiring the prisoner to serve more than a ten years sentence. Let his sentence be commuted to ten years. October 10th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Robert Sampson	San Francisco	Robbery	November, 1877	Four years.

Decision.—Whereas, the Honorable M. C. Blake, Judge of the Municipal Criminal Court of the City and County of San Francisco, who tried and sentenced the said Robert Sampson, has written me as follows (see his letter on file in this office): "On the 15th of December, 1877, in the Municipal Criminal Court, Robert Sampson, having been found guilty of robbery, was sentenced to imprisonment in the State Prison for the term of four years. I now think that a term of three years would have been sufficient, and I respectfully ask your Excellency to change the term imposed to a term of three years. One reason for this request is, that though I think the prisoner was guilty (and I have recently gone through the evidence in the case), the proof was not as conclusive as in many other cases. There is just enough in this point to make me wish I had made his term a year shorter." Let his sentence be commuted to three years. November 11th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Fred'k Richardson	San Francisco	Embezzlement	November, 1875	Ten years.

Decision.—Whereas, the Honorable M. C. Blake, Judge of the Municipal Criminal Court of the City and County of San Francisco, who sentenced the said Frederick Richardson, now asks that his sentence, as originally fixed, may be commuted to a term of eight years, giving as grounds for such request, the following statement (see his letter on file in this office): "On the 13th of November, 1875, in the Municipal Criminal Court, upon a plea of guilty of embezzlement, I sentenced Frederick Richardson to imprisonment in the State Prison for a term of ten years. I have now some question in my mind whether a term of eight years would not have been sufficient, and am inclined to think it would, and this, with the fact that the prisoner's wife and children very much need his assistance, induces me to request Your Excellency to grant a commutation of his term of imprisonment as originally fixed to a term of eight years. I think this would be just;" and whereas, the original term of the said Richardson was, on the 30th day of May, 1876, for meritorious conduct at the fire in the Prison workshops on the 28th day of February, 1876, commuted to eight years. Let his sentence be commuted to six years. November 19th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John W. Burke	Sonoma	Murder, 1st degree	February, 1874	Life.

Decision.—Whereas, the pardon of the said John W. Burke has been earnestly and persistently urged by many of the most intelligent and upright citizens of the locality where the homicide was committed, on the ground, as they allege and believe, that he was insane at the time of and for some time prior to its commission; and whereas, the District Attorney of Mendocino County at the time of the homicide, who prosecuted Burke, asks for the pardon of said Burke, saying: "I was District Attorney at the time, and prosecuted him, and am familiar with all the facts and circumstances of the case, and think from such knowledge that he is legally innocent of the crime for which he is now imprisoned;" and whereas, the Judge before whom he was tried, in response to my inquiry as to his opinion of the mental condition of Burke at the time of the homicide, formed from the testimony given at the trial, says (see his letter on file in this office): "The impression that the evidence made on my mind was as follows: taking

the testimony of the non-professional witnesses, and previous to the examination of the doctors, I thought Burke insane at the time of the commission of the act. But when Doctors Titus and Boyce came to be examined, I changed my opinion. I then thought he was legally amenable to the law;" and whereas, the committees of the Senate and Assembly of the last Legislature on State Prison matters, acting jointly, recommended the pardon of Burke on the ground of his mental derangement (supposed), at the time of the commission of the act; and whereas, though not satisfied from all the information I have been able to obtain, touching Burke's mental condition at the time he committed the homicide, that he ought not to have been held amenable to the law; yet there is in my judgment sufficient doubt as to what the exact state of his mind was, to justify a relaxation of the extreme sentence consequent on a conviction of murder in the first degree. Let his sentence be commuted to ten years. November 20th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Henry Thompson	San Francisco	Counterfeiting	March, 1877	Four years.

Decision.—Whereas, a commutation of the sentence of the said Henry Thompson is now asked for by the Honorable M. C. Blake, Judge of the Municipal Criminal Court, who states, in support of such commutation, the following facts (see his letter on file in this office): "On the 22d of December, 1877, Henry Thompson, who had been found guilty of the crime of uttering and passing a 'counterfeit gold bar,' with intent to defraud, etc., was, in the Municipal Criminal Court, sentenced to imprisonment in the State Prison for the term of four years. He was found guilty April 12th, 1877. On the 4th of May, a motion for a new trial was submitted and taken under advisement. After that the case stood along to the 22d of December, in expectation that another case would be tried, in which Thompson was to be a witness on the part of the people. If he had been a witness in that other case, as he doubtless would have been if it had been tried, the case against him would, I suppose, have been dismissed—I know it was so intended. After awhile it became evident that the other case would not be tried, and then the motion for a new trial was denied, and the prisoner was sentenced as before stated. Thompson thought, as he was willing to be a witness, and as his case was postponed many times, in order that he might be, he should be treated as though he had in fact been a witness. I did not take that view of his case, but I am not now certain that some more allowance should not, under the circumstances, have been made in his favor than was made. That he was willing to be a witness, and had been led to suppose that, in consequence of his testimony to be given, he would be discharged, I did not take into account, but I have no recollection that I considered that the extra seven and a half months' time passed by him in our County Jail, crowded as it then was, was fully equal to a year in the State Prison. I therefore respectfully recommend and request that your Excellency will change the imposed term to a term of three years." Let his sentence be commuted to three years. December 1st, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Wm. Gates	San Bernardino	Murder, 1st degree	June, 1876	Life.

Decision.—Whereas, the pardon of the said William Gates has been asked for by numerous citizens of San Bernardino County, including eleven of the jurors who tried him, and the Judge before whom he was tried; and whereas, the District Attorney who prosecuted him has recommended that his sentence be commuted to eight years; and whereas, the provocation which led the said Yates to take the life of a fellow-man, though no legal justification for such action, was of such a character as to tend directly and powerfully to bring about such a result. Let his sentence be commuted to ten years. December 8th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Alexander Cowdrey	Siskiyou	Robbery	December, 1879	Ten years.

Decision.—Whereas, the pardon of the said Alexander Cowdrey is now petitioned for by numerous prominent citizens of Siskiyou County, on the grounds: 1st, of his good character,

previous to the commission of the crime for which he is now in the State Prison; 2d, of his good conduct during the period he has been in prison; 3d, that he has a wife and children who are sadly in need of such aid as he could render if at liberty; and whereas, in view of the personal good character of the prisoner, and of the fact that he had never before been charged with crime, there is reason to believe that the sentence was severer than the demands of justice or the good of society required, and believing that a sentence of five years would have been a just and reasonable one. Let his sentence be commuted to five years. December 12th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Eli Kelly	Siskiyou	Robbery	December, 1879	Eight years.

Decision.—Whereas, the pardon of the said Eli Kelly is now petitioned for by numerous prominent citizens of Siskiyou County, on the grounds: First—that the said Kelly, prior to the commission of the crime for which he is now in the State Prison, had borne a good character, and, so far as petitioners know or believe, had never been guilty of any crimes; second, that he was but eighteen years of age at the time of his conviction; and whereas, in view of the previous good character and youth of the prisoner, referred to by petitioners and made the basis of their request for his pardon, there is reason to believe that the sentence was severer than sound policy required or the ends of justice demanded, and believing that a sentence of five years would have been a just and reasonable one under the circumstances. Let his sentence be commuted to five years. December 12th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Barth. Reardon	San Francisco	Manslaughter	January, 1877	Eight years.

Decision.—The pardon of the said Bartholomew Reardon is now asked for by the Judge who sentenced him, by the District Attorney who prosecuted him, and six of the jurors who found him guilty, for the reasons set forth in their petition on file in this office; and whereas, I hold those reasons to be sufficient to justify a commutation of sentence to a shorter period. Let his sentence be commuted to five years. December 27th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Winchester Doyell	Sierra	Murder, 2d degree	1873	Thirty years.

Decision.—Whereas, the pardon of the said Winchester Doyell is now asked for by the Honorable G. G. Clough, formerly District Judge of the Tenth Judicial District, and now Superior Judge of Plumas County, on the ground that he ought not to have been convicted of a crime higher than manslaughter, if of any crime at all, and that he has already served a term equal to the average of sentences for that crime; and whereas, the said Doyell was never before convicted of any crime, and manifestly does not belong to the criminal class, and is not naturally disposed to commit crime, and believing that the sentence was unnecessarily severe; and whereas, the said Doyell is now near sixty years of age. Let his sentence be commuted to fifteen years. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Leopold Eckstein	San Francisco	Forgery	1876	Eight years.

Decision.—Whereas, the said Eckstein has had an important clerical position in the prison for several years, in which fidelity and ability were indispensable prerequisites; and whereas, in such position he has been attentive, able, and faithful; and whereas, such service ought to receive proper recognition. Let his sentence be commuted to six years. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
F. J. Springer	Solano	Arson	May, 1877	Ten years.

DECISION.—Whereas, a commutation of the sentence of the said F. J. Springer is now asked for by numerous respectable citizens of the Town of Vallejo, where the crime was committed, to five years, on the ground that the original sentence of ten years was disproportioned to the crime and excessive. Let his sentence be commuted to a term of five years. January 3d, 1880.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
F. S. Van Meter	Butte	Assault to murder	1879	Fourteen years.

DECISION.—Whereas, a commutation of the sentence of the said F. S. Van Meter is now asked for, to a term of five years, by numerous citizens of the vicinity where the offense was committed, including the Judge who sentenced and the District Attorney who prosecuted him, on the ground that the original sentence of fourteen years was excessive. Let his sentence be commuted to five years. January 3d, 1880.

PARDONED FROM COUNTY JAIL.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Anks	Tehama	Resisting an officer	September, 1877	Fine of $50, and an imprisonment of six months in the County Jail.

DECISION.—Whereas, the pardon of the said William Anks is now petitioned for by the District Attorney who prosecuted, and the County Judge who sentenced him, and by numerous other leading citizens of the county in which the offense was committed, including the Sheriff on whom the assault was made; the pardon being asked by the petitioners on the ground of the good conduct of the prisoner since conviction, and his good character previous to the commission of this offense; and whereas, he has paid the fine imposed on him, and has now served in the County Jail nearly two-thirds of the term to which he was sentenced. January 4th, 1878.

Name of Prisoners.	County.	Crime.	Sentenced.	Term.
Ah Gong, Ah Gim, Ah Way, Ah Lee, Ah Dung, Ah Foo, Ah Aye, Ah Hung, Ah Chung, Ah On, Ah Gone, Ah Ginn, Ah Chick, Ah Sing, Ah Chung, Ah Fook, Ah Fow, Ah Lane, Ah You, and Ah Who	Colusa	Violation of town ordinance	December, 1877	Fine of $50, or, in default of payment of fine, to work fifty days in chain gang.

DECISION.—Whereas, the pardon of the said Ah Gong, Ah Gim, Ah Way, Ah Lee, Ah Dung,

Ah Foo, Ah Aye, Ah Hung, Ah Chung, Ah On, Ah Gone, Ah Ginn, Ah Chick, Ah Sing, Ah Chung, Ah Fook, Ah Fow, Ah Lane, Ah You, and Ah Who is petitioned for by the principal citizens of the Town of Colusa, in a petition now on file in this office; now, therefore, for the reasons set forth in said petition, I do pardon the said Ah Gong, Ah Gim, Ah Way, Ah Lee, Ah Dung, Ah Foo, Ah Aye, Ah Hung, Ah Chung, Ah On, Ah Gone, Ah Ginn, Ah Chick, Ah Sing, Ah Chung, Ah Fook, Ah Fow, Ah Lane, Ah You, and Ah Who. January 9th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Thomas Ryan	San Francisco	Obtaining goods on credit under false pretenses	Nov. 10, 1877	Fine of $75 or 30 days imprisonment in default of payment of said fine, and also six months imprisonment in the county jail.

Decision.—Whereas, the pardon of the said Thomas Ryan is now asked for by the Judge who tried, and the attorney who prosecuted him, by the prosecuting witness who suffered by his crime, and by a numerous body of prominent citizens of the City of San Francisco, for reasons set forth in their petition now on file in this office. January 22d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Melquiades Contreras.	San Bernardino	Dealing a banking game	November, 1877	A fine of $274 and be imprisoned until said fine was paid, not exceeding 274 days.

Decision.—Whereas, the pardon of the said Melquiades Contreras is asked for in a petition numerously signed by citizens of San Bernardino County, it being stated in said petition that "the petitioners believe, and so state the fact to be, that said Contreras was wholly ignorant of the law against gambling, and that he would not have engaged in the game if he had known the law, and that he will not repeat the crime if pardoned for this offense; that he has borne a good reputation prior to this time, and industriously worked at his occupation as a blacksmith; and that he is only twenty years of age;" and whereas, the Judge before whom the said Contreras was tried has advised his pardon, saying: "If it had been in my power, it being his first offense, I would have made the fine very light, but the law left me no discretion below a fine of two hundred dollars and costs." February 16th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Frederick Kalber	Solano	Assault and battery	January, 1878	One hundred days.

Decision.—Whereas, the pardon of the said Frederick Kalber is now petitioned for by the Justice of the Peace who tried and sentenced him, and as I am informed by nearly the entire community in which the offense was committed—said petition being based on the assumption that the sentence was disproportioned to the offense, and unnecessarily severe. March 4th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Edward H. Bailey	Alameda	Battery	December, 1877	One hundred and twenty-five days

DECISION.—Whereas, the pardon of the said Edward H. Bailey is now asked for by the ex-Police Judge of the City of Oakland who sentenced him, the present Police Judge, the City Physician, and five of the Councilmen of said city, the said request being based on the grounds: 1st, that the health of the said Bailey is being seriously impaired by his imprisonment; and, 2d, that the punishment he has already suffered has been sufficient for his crime. April 10th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Meyer Stein	San Francisco	Receiving stolen property, knowing it to have been stolen	January, 1878	Six months.

DECISION.—Whereas, Charles B. Darwin, Esq., Assistant District Attorney, who prosecuted the said Meyer Stein before the Municipal Criminal Court, has joined with the friends of said Stein in asking his pardon, basing his action in the premises, on a doubt as to the guilt of the said Stein, as appears from a letter of the said Darwin, on file in this office. April 13th, 1878.

Name of Prisoner.	County.	Grime.	Sentenced.	Term.
James Gray	San Francisco	Creating disturbance and using weapons	March, 1878	Fine of $125, or 60 days imprisonment.

DECISION.—Whereas, the said James Gray has now been in the County Jail about two-thirds of the period for which he was sentenced, in lieu of the payment of one hundred and twenty-five dollars; and whereas, the said James Gray is an enlisted man, in Company D, First United States Cavalry, and Captain E. V. Sumner, Captain of said company, has asked for his pardon, that he may join his company. May 1st, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
John Long	San Francisco	Creating disturbance and using weapons	March, 1878	Fine of $125, or 60 days' imprisonment.

DECISION.—Whereas, the said John Long has now been in the County Jail about two-thirds of the period for which he was sentenced, in lieu of the one hundred and twenty-five dollars; and whereas, the said John Long is an enlisted man in Company D, First U. S. Cavalry, and Captain E. V. Sumner, Captain of said company, has asked for his pardon, that he may join his company. May 1st, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Henry Beatty	San Francisco	Violation of the provisions of Section 652 of the Penal Code	----------	Fine of $100, or fifty days imprisonment.

Decision.—Whereas, the pardon of the said Henry Beatty, who is a private in Company B, Second Regiment, Second Brigade, N. G. C., is now asked for by the Captain of the Company, and the General of the Brigade, for the reasons set forth in their respective communications in relation thereto, now on file in this office. May 2d, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
George W. Shuster	Sonoma	Assault with a deadly weapon with intent to do great bodily injury	October, 1877	Three months and a fine of $275, or in default of payment of fine imprisonment at the rate of one day for each dollar of said fine until paid.

Decision.—Whereas, the pardon of the said George W. Shuster is now petitioned for by numerous citizens of Sonoma County, including the County Judge who sentenced him. The said County Judge, in a letter on file in this office, says: "When I sentenced him I was informed that he could pay a fine, and I gave him three months and two hundred and seventy-five ($275) dollars fine. The three months expired on the 15th day of January last, and he is now serving out the fine. I would not have made the imprisonment as long as it will be had I known he could not pay the fine. Shuster is a man of good character. I think he should be released. A petition has already been sent to your Excellency and I hope you will pardon him. In my judgment he has been sufficiently punished." May 11th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Henry Lawton	Solano	Petit larceny	March, 1878	One hundred and twenty days.

Decision.—Whereas, the Grand Jury for Solano County, at the April term of the County Court of said county, did investigate another charge brought upon the same facts before it, and did ignore said charge; and whereas, the members of said Grand Jury, on a petition, under date of April 2d, 1878, now on file in this office, make statements as follows, to wit: "We, the individual members of the Grand Jury aforesaid, came to the unanimous conclusion, under all the circumstances of the case, that the said sentence of one hundred and twenty days, considering the extreme youth of the said Henry Lawton—he being but fifteen years of age—was and is excessive, and hereby pray that your Excellency may pardon the said Henry Lawton." June 8th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
J. Rosenthall	Sacramento	Buying stolen goods, knowing them to have been stolen	January, 1878	One year.

DECISION.—Whereas, the pardon of the said J. Rosenthall has been heretofore recommended by many respectable citizens of the City of Sacramento, including the County Judge who sentenced, and the District Attorney who prosecuted him; and whereas, the Grand Jury for the county, which has just adjourned, has also in its report recommended such pardon. July 26th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Samuel Schuyler	Colusa	Battery	September, 1878	Ninety days.

DECISION.—Whereas, the pardon of the said Samuel Schuyler is now asked for in a petition signed by numerous respectable citizens of the Town of Colusa, and is advised by the District Attorney who prosecuted, and the Justice of the Peace who sentenced him, on the grounds and for the reasons set forth in the said petition. October 15th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Curley Taylor	Marin	An attempt to rescue a prisoner who was in charge of a Peace Officer, and charged with misdemeanor and battery	July, 1878	Six months, and pay a fine of $500; and also imprisonment of three hundred days for the crime of battery.

DECISION.—Whereas, the pardon of the said Curley Taylor is now asked for on the ground, among other reasons, that he is in danger of losing his eyesight from injuries received at the time of the commission of the misdemeanor for which he is now being punished, and that he cannot receive the care and treatment necessary to avert such calamity while confined in jail; and whereas, the County Judge, the District Attorney, and Sheriff of the county in which said Taylor is imprisoned, and the Justice of the Peace who convicted and sentenced him, advise his pardon. December 18th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Ah Fink	Nevada	Gaming	November, 1878	To pay a fine of $200, or be confined in the County Jail one hundred days.

DECISION.—Whereas, the pardon of the said Ah Fink is now asked for by the District Attorney

who prosecuted and the Judge who sentenced him, and by the Sheriff and his deputies who have charge of him, and by many other prominent citizens of Nevada County, on the grounds: that he is sick and cannot long survive; that, though he is a source of much expense to the county for medical treatment, he cannot be properly taken care of in the jail; that his condition makes him a nuisance in the jail which, out of regard for the other persons as well as for the keepers, ought to be removed; and that his countrymen agree, if he is discharged, to take care of him. January 21st, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Creamer	Tulare	Gaming	December, 1878	A fine of $200 and costs of prosecution, and in default of the payment of said fine, to be imprisoned in the County Jail at the rate of one day for each dollar of the fine.

Decision.—Whereas, the pardon of the said William Creamer is now petitioned for by numerous citizens of Visalia, including the District Attorney who prosecuted him, as well as most, if not all, the other county officers, on the ground especially that, since his conviction, his health has become so impaired that his removal from the County Jail to the County Hospital has become necessary; and whereas, the County Physician, in a letter on file in this office, says: "In reference to the case of William Creamer, the prisoner removed from the County Jail to the County Hospital and now under treatment, I hereby certify that the disease with which he is afflicted is of such a character that, in my opinion, to return him to confinement in the County Jail will prove detrimental to his health, and in all probability fatal to his life;" and whereas, the County Judge who sentenced the said William Creamer, in a letter also on file in this office, says: "For the reasons given by the County Physician, I recommend the case of the said Creamer to the favorable consideration of the Governor, and join petitioners in requesting his pardon." March 8th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Smith	Butte	Petit larceny	October, 1878	To pay a fine of $250, with alternative of imprisonment in County Jail until paid, at the rate of $1 00 per day, but not exceeding two hundred and fifty days.

Decision.—Whereas, the pardon of the said William Smith is now asked for in a petition on file in this office, in which the petitioners say: "Your petitioners, residents, citizens, and taxpayers of said township, would respectfully represent to your Excellency that they are well acquainted with said William Smith, who has for several years been a resident among us; that it is his first offense, as far as known; that he was considerably intoxicated at the time of committing the offense, and, as has since transpired, was incited and prompted thereto by another person; that he has now been imprisoned five months on said sentence; that his conduct during said time has been exemplary; that the District Attorney who prosecuted, and the magistrate who sentenced him, unite with us in this prayer for his relief;" and whereas, the said petition, in addition to the names of the District Attorney who prosecuted and the magistrate who sentenced him, bears those of the District and County Judges, of most, if not all of the county officers, and other prominent citizens. March 19th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Walter Brand	Butte	Disturbing the Peace	September, 1879.	Fine of $60, or 60 days imprisonment in County Jail.

DECISION.—Whereas, the pardon of the said Walter Brand is now petitioned for by the Justice of the Peace who sentenced him, by the District Attorney of Butte County, and by numerous other prominent citizens of the Town of Oroville, for the reasons set forth at length in their petition now on file in this office. October 15th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
William Stanley	Mariposa	Battery, two charges	Sept. 20, 1879	Pay a fine of $120, or imprisonment in the County Jail for sixty days.

DECISION.—Whereas, the pardon of the said William Stanley is now asked for by the County Judge, the District Attorney, the Sheriff, and other prominent citizens of the county, who, in their petition now on file in this office, say: "The offense was not serious; the prisoner promises to be a peaceable, law-abiding citizen, and his punishment already has been sufficient to satisfy the ends of justice. In addition to these reasons, Stanley is the only prisoner in the County Jail, and his detention there is productive of heavy expense, which our county can ill afford to bear." November 7th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Joseph Hozier	Colusa	Battery	September, 1879.	Five hundred days.

DECISION.—Whereas, the pardon of the said Joseph Hozier is now asked for by most of the leading citizens of the Town of Colusa, including the Justice of the Peace who sentenced him, on the ground that his family is in a destitute and suffering condition, and their support must become a public charge, unless he is discharged from prison, to the end that he may labor for their support. December 11th, 1879.

FROM HOUSE OF CORRECTION AND CITY PRISON.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
W. J. Henry	San Francisco	Burglary	March, 1877	Two years.

DECISION.—Whereas, the pardon of the said W. J. Henry is now asked for by D. J. Murphy, the District Attorney who prosecuted him, for reasons as follows (as appears by his letter on file

in this office): "Henry is a young man, aged about 22 years. His parents reside in Indiana, and are said to be highly respectable. Young Henry came to this State a few months before the commission of the crime for which he was convicted, and engaged in honest labor for a time, but, failing to get steady employment, he fell in with two expert burglars named Schultz and Keefe, who, it seems, induced him to join them in the commission of the burglary in question, which was committed by entering the building used as the place of business of Thomas M. Antisell, in this city. The party was interrupted in the act, and, as frequently happens, the two hardened criminals escaped, and the boy was arrested, was indicted, and pleaded guilty, as above stated. Keefe and Schultz afterwards run a successful career of crime in different parts of the State and in Oregon, but were finally arrested in this city, tried, and convicted for the burglary in entering Antisell's premises, and were, on Saturday last (in December, 1877), sentenced to the State Prison. It was mainly on the testimony of young Henry that these men were brought to justice. From the time of his arrest he has done all in his power to aid the officers of the law. While I have held out to him that I had not the power to release him, I, as well as Captain Lees, who has had the prosecution of these men in his charge as a police officer, have promised to represent the case to your Excellency as especially worthy of executive clemency. His character prior to this offense has been good, and if he is now restored to liberty I do not think he will return to vicious courses. Money has been furnished, as I am informed, to send him to his parents, who, though not aware of his troubles, are very anxious for his return." This pardon is granted on the express condition that the person pardoned shall forthwith leave the State and remain absent therefrom at least one year from the date hereof. May 10th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Barney Conway	San Francisco	Misdemeanor	October, 1878	Three months.

Decision.—Whereas, the pardon of the said Barney Conway is now asked for by the Hon. Davis Louderback, the Judge who sentenced him, who in his letter asking the pardon says: "On the 2d day of October, 1878, in the Police Judge's Court of the City and County of San Francisco, one Barney Conway was tried on a charge of drunkenness, and one witness was sworn and gave testimony. The testimony was in effect that the accused was arrested in a public place in a state of drunkenness, that he was a vagrant whose drunkenness was habitual, etc. He was asked if he desired to ask the witness any questions concerning the matter, or concerning what the witness testified—whether he had any witnesses he wished to introduce—whether he desired to testify in his own behalf, or make any statement about the matter—whether he had anything to offer for the consideration of the Court. Answering all these questions in the negative, he was adjudged guilty, and ordered to appear for sentence the next day. On October 3d, 1878, no motion for a new trial being made, and no reasons being assigned why judgment should not pass, he was sentenced to three (3) months imprisonment in the House of Correction of the City and County of San Francisco, as a punishment for habitual drunkenness and vagrancy. The witness has now found that he made a mistake in testifying that he was addicted to vagrancy and habitual drunkenness, and forthwith notified me, and I have investigated the same. In respect to habitual drunkenness and vagrancy, it is a case of mistaken identity. There is now no dispute as to his drunkenness and misconduct when arrested, but it appears he is not a common drunkard or vagrant. He has already suffered sufficient punishment for his drunken misconduct, and as a matter of justice I recommend that your Excellency grant a pardon." November 4th, 1878.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Anthony Hammond	San Francisco	Indecent exposure of person	March, 1879	Six Months.

Decision.—Whereas, the Grand Jury for the City and County of San Francisco asked for the pardon of the said Anthony Hammond, for the reasons set forth in their petition now on file in this office. April 25th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Frank H. Murphy	Alameda	Drunkenness and assault and battery on his wife	May, 1879	One hundred and eighty days.

DECISION.—Whereas, the pardon of the said Frank H. Murphy is now asked by the Supervisors of the county, and by the Mayor and other prominent citizens of the City of Oakland, who, in their petition, say: "Our reasons for asking your Excellency to exercise the pardoning power in this case are, that Mr. Murphy has a wife and five children solely dependent on his daily labor as a barber for their support; that since his incarceration his family have been supported by charity, and unless he is liberated will continue to require such support for the next five months, thus making the penalty operate more harshly on his wife and children than upon himself. No censure is implied here as to the officers of the law. Mr. Murphy is a man addicted to periodical sprees, and the sentence was doubtless intended for his good, but we think it has taught him a lesson, and that his having already been confined thirty days will be deemed sufficient punishment. At all events, motives of humanity on behalf of his dependent family induce us to say to you that we think this a proper case for the exercise of the pardoning power, and, in behalf of his family, respectfully ask your Excellency to grant it." June 17th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Julius Taylor	San Francisco	Petit larceny	June, 1879	One hundred and twenty-five days.

DECISION.—Whereas, the pardon of the said Julius Taylor is now asked for by numerous leading citizens of San Francisco, on the ground that they do not think he intended to commit larceny, but that he believed when he took the box of fruit for which he was convicted of larceny, that he took it in obedience to the order of the owner thereof; and whereas, the Honorable Davis Louderback, the Judge of the Police Court of the City and County of San Francisco, who convicted and sentenced him, though he does not accept the theory of his innocence, says (see letter on file in this office): "If I had known at the time of his sentence what I know now, or rather believe, concerning him, I believe I would have imposed a lighter penalty. I recommend that he be pardoned, on the ground that he has now been sufficiently punished for the offense." August 11th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
Frank L. Davison	Alameda	Petit larceny	August, 1869	Sixty days.

DECISION.—Whereas, the District Attorney who prosecuted him, the arresting officers, the Police Judge before whom he was tried, the County Judge of the county, and other citizens of the county, unite in a petition for a pardon, on the grounds that, if the prisoner can be permanently removed from the company of bad companions, and placed under proper discipline, he may be reformed, and that looking to such a result a situation has been obtained for said Davison on board of a ship, which sails on or about the thirtieth of August, instant, from the harbor of San Francisco. August 20th, 1879.

Name of Prisoner.	County.	Crime.	Sentenced.	Term.
G. W. Bartles	Alameda	Battery	September, 1879	One hundred and fifty days.

DECISION.—Whereas, the pardon of the said G. W. Bartles is now asked for by the Police Judge of the City of Oakland, who sentenced, and the Deputy District Attorney, who prosecuted him, and by the County Judge of Alameda County, as well as by other citizens. December 3d, 1879.